UNIVERSITY OF CAMBRIDGE
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POLICY LINKS

NEW INDUSTRIAL CAPABILITIES FOR NEW ECONOMIC GROWTH:

A Review of International Policy Approaches to Strengthening Value Chain Capabilities

A REPORT TO THE DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY (BEIS)

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New industrial capabilities for new economic growth: a review of international policy approaches to strengthening value chain capabilities

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Continuous discussion with BEIS helped shape the focus of the report. Initial findings were presented to BEIS in July 2017, and an interim report submitted in August 2017. This report was completed before the publication of the UK Industrial Strategy White Paper in November 2017.

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Executive summary

Opportunities exist to unlock the competitiveness and innovation potential of UK sectors by supporting the ecology of domestic suppliers, particularly in manufacturing. Supplier firms are not only a source of materials, components, and subsystems, but also of new technologies, knowledge-intensive services, and ideas. However, UK supply chains in a number of sectors remain relatively weak, with lower levels of domestic sourcing than competitor countries. Large disparities exist between the levels of productivity of leading firms and the 'long tail' of lower performing firms along the supply chains. A large proportion of firms, particularly SMEs, find it harder to engage in R&D and innovate. Concerns have been raised that, without a healthy ecology of domestic suppliers, technologies developed in the UK might be taken abroad for industrialisation.

The objective of this report is to inform policy efforts, aimed at promoting industrial innovation and competitiveness, by providing insights into international policy practices and approaches. The report discusses key concepts and definitions relevant to understanding the role of domestic suppliers in modern industries, reviews programmes and initiatives in selected countries, and suggests policy implications for the UK.

Characterising a 'sector', as a group of large firms with a well-defined set of suppliers runs the risk of oversimplification. Modern industrial systems involve complex interactions and interdependencies between sectors, firms, and technologies. As such, it is increasingly challenging for policy makers to appropriately understand the role of suppliers within and across sectors, the market failures constraining their growth, and the potential for policy interventions to strengthen their capabilities.

In order to establish a common language and key dimensions for analysis, the concept of 'value chain capabilities' is introduced. 'Value chain capabilities' are defined in the context of this study as *the collective ability of firms in the value chain to respond to value capture opportunities and deliver products and services at the specifications required by customers*. The concept can be used to unpick two useful dimensions to frame and compare policy interventions: (a) the opportunity areas for increased value capture (opportunity dimension); and (b) the capabilities needed in the value chain to address those opportunity areas (capability dimension).

Four opportunity areas of particular relevance to the UK are highlighted. While this is not an exhaustive list and some overlap exists, this simplified categorisation has proved useful to distinguish different policy missions, and to structure the review of international approaches presented in this report. These areas include:

1. **Exploiting domestic supply opportunities – value capture from efficiency gains & improved trade balance.** Including opportunities for strengthening the domestic supply base in order to help UK sectors reduce delivery times, inventory costs, and supply risks. The CBI estimates that strengthening supply chains could add £30bn to the UK economy by 2025. Specific sectoral opportunities for UK suppliers include an estimated £4bn in automotive, and £4.7bn in nuclear new build projects.
2. **Technology diffusion along value chains – value capture from increased technology adoption.** Including opportunities for the 'long tail of unproductive firms' across sectors to adopt new more efficient technologies. Regions and countries with higher rates of new technology adoption are likely to become more attractive industrial locations.
3. **Promoting R&D among SMEs in the value chain – value capture from a more inclusive national innovation system**. Including opportunities to build R&D partnerships with SMEs, and exploit the potential of these partnerships as new sources of ideas and breakthroughs. Increasing SME engagement in R&D is essential if national targets on research investment are to be achieved.
4. **Enabling the development of the value chains of the future – value capture from industrialisation of emerging technologies.** This includes opportunities for strengthening the UK's 'industrial commons', to ensure that future value chains of emergent technologies and sectors where the UK has a leading edge – such as synthetic biology, biopharma, etc. – create a positive economic impact in the UK.

A review of international policy efforts reveals a variety of approaches to building value chain capabilities, relevant to the four opportunity areas outlined above. Over 60 national initiatives and programmes – most of them government-led – have been reviewed, and 13 of them have been selected for more detailed analysis. Insights from the review can help inform policy making in the UK by illustrating the variety of actions, institutions and levels of funding that have been deployed to support value chain capability development internationally. To some extent, the case studies presented in the report also provide indications of what has been considered to be effective in other countries.

Drawing from the conceptual discussions presented in the study, and the analysis of international policy efforts, a number of observations and implications emerge from the study:

- **The need to build an evidence base on the opportunities and challenges across UK sectors for an effective policy design and delivery.** Effective design of support programmes and initiatives requires the building of a robust evidence base on particular value capture opportunities for UK value chains, the challenges constraining firms from pursuing them, and how policy interventions might make a difference. Systematically collecting evidence on the four opportunity areas, discussed in this report across sectors, could be a first step in helping policy makers to identify cross-cutting themes and establish priorities for action – both in terms of new programme design, as well as institutional capability building.
- **The need to ensure that the national institutional infrastructure enables decentralised policy delivery – including the ability to engage with firms across regions.** Efforts to nurture institutions might be as, if not more, important than the establishment of new programmes and initiatives. Effective support strategies require a long-term approach to building institutions with the size, coverage and financial flexibility required to deliver the intended support. Institutions can also play a critical evidence gathering role by feeding into the policy making process first-hand insights into the changing needs, and capabilities of firms and sectors across regions. Decentralised facilities might be required, as well as partnerships between research and technology organisations, industry associations, professional bodies, and universities.
- **The need to systematically account for the particular challenges faced by SMEs for engaging in research and innovation activities.** Enhancing national industrial competitiveness might only be possible if all types of companies, leaders and followers, are able to participate in the transformations made possible through innovation. Yet evidence suggests that smaller firms find it more difficult to engage in innovation. SMEs usually do not have the time, capacity or funds to keep up-to-date about existing sources of support. The international experience reveals explicit efforts to promote SME engagement through a variety of modalities and technical mechanisms.
- **The need for efforts beyond R&D and knowledge generation to ensure policy impact.** Ensuring that policy efforts achieve their intended impact requires a broad conception of innovation. Beyond funding R&D, ensuring that innovation programmes achieve their intended impact might also require support for knowledge diffusion and application, in areas including: pilot line and test-bed demonstration, development of skilled technicians and engineers, regional firm consortia formation, SME capacity building and participation in new supply chains, and the attraction of FDI.
- **The need for performance metrics beyond productivity and R&D.** Policy makers should assess whether performance indicators properly account for the systemic nature of the modern industries and the dynamics of innovation within them. Relying solely on R&D-related metrics (such as numbers of publications and patents) might not provide meaningful guidance regarding the impact of innovation and competitiveness policies. The cases reviewed in this study reveal that, compared to the UK, other countries place less emphasis on productivity measures. A variety of performance indicators are used, with more careful attention being made to the particular capability challenges that institutions and programmes seek to address.

The report concludes by emphasising that evidence on opportunities and capability gaps across sectors could help policy makers identify cross-cutting themes and establish priorities for action. Such considerations appear particularly relevant to the UK in the context of ongoing industrial strategy efforts and 'sector deals'.

1

Introduction

The UK Industrial Strategy Green Paper recognises the importance of an "ecology of suppliers" for the success of the UK industrial sectors

The UK Industrial Strategy Green Paper[1] recognises that the competitiveness of UK industrial sectors often depends on the presence of a "vibrant, competitive supply chain of smaller companies" supporting major players. It argues that a "vigorous ecology of suppliers" represents a common resource facilitating the operation of larger firms, and recommends that deliberate steps are taken to support this "ecology of suppliers" to support the competitiveness of UK industrial sectors.

However, understanding the structure and configuration of this "ecology of suppliers" is increasingly complex in the context of modern industries

Characterising sectors as a group of large firms, with a well-defined set of suppliers that come together to produce homogeneous products, runs the risk of oversimplification[2]. Modern industries often involve complex interactions, and interdependences between a range of firms that provide a variety of components, material, production systems and subsystems, producer services and product-related service systems[3,4]. Innovations made in one industry might have an impact in others, and so the boundaries of "sectors" and the configurations of the relevant "ecology of suppliers" are in continuous reconfiguration[5]. Consequently, the boundaries between manufacturing and services are becoming increasingly blurred. The expansion of software and information content, for instance, means that electronics and software firms are becoming a more important component and source of value capture across a range of sectors, from automotive to chemicals and medical devices[6].

[1] HMG (2017). Building our Industrial Strategy. HM Government Green Paper.
[2] Rosenberg, N. (1976). Perspectives on Technology. Cambridge University Press. Cambridge, UK.
[3] Tassey, G. (2010). Rationales and mechanisms for revitalizing US manufacturing R&D strategies, Journal of Technology Transfer.
[4] PCAST (2011). Ensuring American Leadership in Advanced Manufacturing. President's Council of Advisors on Science & Technology. Executive Office of the President.
[5] NAE (2015). Making Value for America: Embracing the Future of Manufacturing, Technology, and Work. Committee on Foundational Best Practices for Making Value for America. National Academy of Engineering.
[6] IA2030 (2013). ITEA ARTEMIS-IA High-Level Vision 2030: Opportunities for Europe.

This makes it challenging to characterise the 'system' that policy interventions are expected to influence

Linkages and interdependencies in modern sectors are not fully captured by official statistics based on traditional sector boundaries[7]. While concepts such as "supply chain" and "value chain" can help go beyond the boundaries of individual sectors and technologies, as traditionally defined, they are not always appropriately defined, or used consistently in the academic and policy literature. The lack of clear definitions make it challenging for policy makers to characterise the "system" that policy interventions, aimed at promoting the competitiveness of modern industrial sectors, (not least the "sector deals" announced in the Industrial Strategy Green Paper) are supposed to influence, as well as the market failures constraining its growth, and the potential role for government to support its competitiveness.

This report aims to inform UK policy development by providing insights into international policy practice, with a focus on opportunity areas that appear of particular importance to promote the competitiveness of UK industrial sectors

It aims to provide insights into policy interventions that can help strengthen industrial value chain capabilities – in terms of competitiveness, innovation and productivity – by reviewing international approaches and practices. The report also draws on insights from the academic literature to clarify terminology, and help characterise and contrast the policy initiatives and the programmes reviewed.

Case studies are presented of policy initiatives and programmes aimed at strengthening value chain capabilities across opportunity areas that appear of particular importance to the UK: (1) exploiting domestic supply opportunities; (2) technology diffusion along manufacturing value chains; (3) promoting R&D among SMEs in the value chain; and (4) enabling the development of the value chains of the future. These areas have been defined in consultation with the Department for Business, Energy & Industrial Strategy (BEIS).

While the report argues that opportunities exist to learn from international practice, the importance of understanding differences in national contexts is particularly emphasised.

The report is structured as follows:

- **Section 2** discusses key concepts and definitions relevant to understanding the structure of the configuration of modern industries, with the intention of framing the "system" that policy interventions are expected to influence. **Appendix 1** complements this section with a long list of relevant definitions.
- **Section 3** discusses four opportunity areas for strengthening value chain capabilities in the UK.
- **Section 4** presents a selection of case studies, categorised across the four opportunity areas, described in Section 3. **Appendix 2** complements this section with a long list of case studies.
- **Section 5** discusses findings from the case studies and policy implications.
- **Section 6** provides concluding remarks.

[7] BIS (2012). Industrial Strategy: UK Sector Analysis. Department for Business, Innovation & Skills. London.

2

Basic Concepts and Definitions:

Framing the 'system' that policy interventions are expected to influence

This section introduces key concepts and definitions that are useful to characterise the "system" that policy interventions, aimed at promoting the competitiveness of modern industrial sectors, are expected to influence. In particular, the concept of "value chain capabilities" is introduced to characterise the relationship between the competitiveness of "sectors" and the "ecology of suppliers" within them. **Appendix 1** complements this section with a long list of relevant definitions.

Characterising modern industries and the role of the "ecology of suppliers" within them is increasingly complex

The "**system**" that policy interventions are expected to influence, in order to improve industrial innovation and competitiveness, is increasingly complex. Modern industries often involve complex interactions and interdependences between a range of firms that contribute a variety of components, materials, production systems and subsystems, producer services, and product-related service systems[8]. Innovations made in one industry might have an impact in others and, as such, the boundaries of a "sector" – and the configurations of the relevant "ecology of suppliers" within it – are in continuous reconfiguration[9].

As such, characterising a sector, as a group of large firms with a well-defined set of suppliers, runs the risk of oversimplification[10]. Industries are better represented as an integrated set of dynamic interdependencies between firms, technologies and capabilities that might cut across sectors[11].

Because of this complexity, it is increasingly challenging for policy makers to appropriately understand the role of suppliers within and across sectors, the market failures constraining their growth, and the potential for policy interventions to strengthen their capabilities.

The concept of "value chain capabilities" is used in the context of this study to frame policy efforts aimed at enhancing industrial competitiveness and innovation

Value chain capabilities are defined in the context of this study as *the collective ability of firms in the value chain to respond to value capture opportunities and deliver products and services at the specifications required by customers*. The concept can be used to unpick two useful dimensions to frame and compare policy interventions: (a) the opportunity areas for increased value capture (opportunity dimension); and (b) the capabilities needed to address those opportunity areas (capability dimension).

Policy efforts might be required to address market and system failures constraining value chain actors from pursuing specific value capture opportunities. Different efforts might be required depending on the nature of these failures, and the way in which they are implemented might be dictated by local institutional contexts. The international comparison presented in this report provides insights into the different approaches and practices, adopted by programmes found in the international experience, to build value chain capabilities in order to address particular opportunities for increased value capture.

In the remainder of this section, a number of concepts and definitions, helpful to characterise this "system" and reveal areas of policy focus, are considered. Concepts that help better understand the relationship between "sectors", and the "ecology of suppliers" underpinning their competitiveness, are particularly relevant.

[8] Tassey, G. (2010). Rationales and mechanisms for revitalizing US manufacturing R&D strategies, Journal of Technology Transfer.
[9] NAE (2015). Making Value for America: Embracing the Future of Manufacturing, Technology, and Work. Committee on Foundational Best Practices for Making Value for America. National Academy of Engineering.
[10] Rosenberg, N. (1976). Perspectives on Technology. Cambridge University Press. Cambridge, UK.
[11] PCAST (2011). Ensuring American Leadership in Advanced Manufacturing. President's Council of Advisors on Science & Technology. Executive Office of the President.

While definitions of manufacturing vary widely in breadth and scope, the 'systems nature' of manufacturing is increasingly recognised in the context of advanced industries

It is useful to first consider the definition of the term "manufacturing". In its most basic form, manufacturing is viewed as "a process to make and produce goods using machinery"[12], or as "the process of converting materials into usable products through human skill and knowledge"[13]. In the context of increasing industrial complexity, however, more recent definitions tend to recognise the 'systems nature' of manufacturing and its key elements and sub-systems[14] (Box 1).

Box 1. What do we mean by manufacturing?

- "To make or produce goods in large quantities, using machinery" (Oxford Dictionary, 2017)
- "The process of converting materials into usable products through human skill and knowledge" (National Academy of Engineering, 2012)
- "…a business system encompassing all activities required to deliver products that meet customer needs… extends from R&D, design, engineering, to production, finance, sales, marketing, and after-sales service… extends beyond any single enterprise, across increasingly global supply chains and business networks" (Canadian Manufacturers & Exporters, 2005)
- There is increasing recognition of the complex interactions and interdependencies between industries, technologies and services associated with the manufacture of many modern products, which themselves are often highly complex systems in their own right (PCAST, 2011; Tassey, 2010; Brecher, 2012)

… which has implications for the way we define 'manufacturing sectors'

The increasing complexity of modern industries has important implications for the way we think about 'manufacturing' and 'manufacturing sectors'. For statistical and analytical purposes, it is necessary to group manufacturing firms together on the basis of common features, such as their final products and sector boundaries (e.g. Standard Industrial Classification or 'SIC' codes). Yet the traditional boundaries between manufacturing industries, where firms turn physical raw materials into 'tangible' products, and service industries, where firms provide products that are not 'tangible', are becoming more blurred. In fact, in some industries, services are becoming an increasingly important revenue stream for manufacturing firms[15]. The expansion of software and digital information content, for instance, means that software and related service firms are becoming increasingly intertwined with other firms, across a range of sectors, from automotive to chemicals and medical devices[16]. As such, a strict distinction between manufacturing and service industries can lead to a false dichotomy[17] (Box 2).

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[12] Oxford English Dictionary (2017). Manufacture.

[13] NAE (2012). "Making things: 21st century manufacturing & design", report of a Symposium of the National Academy of Engineering, National Academies Press.

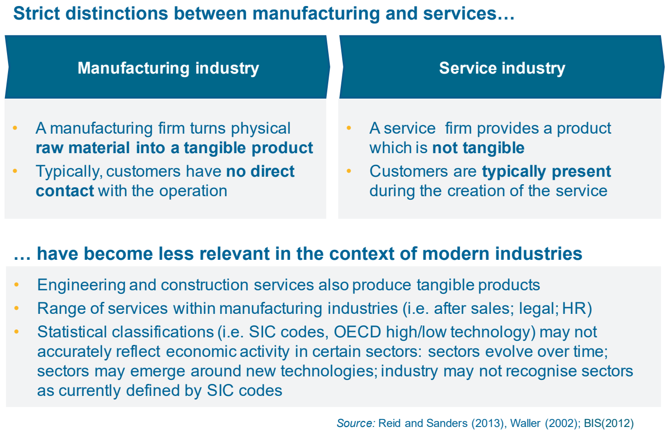
[14] O'Sullivan, E. (2011), "A review of international approaches to manufacturing research", University of Cambridge Institute for Manufacturing, Cambridge, United Kingdom.

[15] Neely, A. Benedetinni, O. & Visnjic, I. (2011). The Servitization of Manufacturing: Further evidence. 18th European Operations Management Association Conference. Cambridge, UK.

[16] IA2030 (2013). ITEA ARTEMIS-IA High-Level Vision 2030: Opportunities for Europe.

[17] Waller L. W. (2002). Operations Management: a supply chain approach. 2nd Edition. Thomson.

Box 2. Manufacturing and services – blurring boundaries



Industries are often represented in terms of 'supply chains' and 'value chains' of activities – which are distinct yet complementary concepts…

Box 3. Key points regarding definitions of 'supply chain' and 'value chain':

- No agreement with respect to definitions
- Both narrow and broad definitions can be found in the literature
- Potentially overlapping but value in seeing them as complementary concepts

While concepts, such as "supply chain" and "value chain", are useful to go beyond the boundary of individual sectors and technologies, as traditionally defined, they are not always appropriately defined, or used consistently in the academic and policy literature. There is no agreement in the economics and management literature about the definitions of either 'supply chain' or 'value chain', and the two concepts often overlap. Although these terms have both narrow as well as broad definitions, and they are often used interchangeably, there is value in highlighting their distinctions and discussing how they might complement each other (Box 3).

Definitions of 'supply chain' tend to focus on the sequence of activities, transformation processes and network of actors involved in production…

The basic definition of a supply chain is "the sequence of processes involved in the production and distribution of a commodity"[18]. Similarly, narrow definitions see supply chain as a set of independent firms involved in manufacturing a product, and delivering to the end user, including "raw material and component producers, product assemblers, wholesalers, retailer merchants and transportation companies"[19].

Broader definitions go beyond the flow and transformation of materials across firms, and see a supply chain as "a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer"[20]. Furthermore, broader definitions recognise that intermediary producers, in a

[18] Oxford Dictionary (2017). Supply chain.
[19] La Londe and Masters (1994). "Emerging Logistics Strategies: Blueprints for the Next Century", *International Journal of Physical Distribution and Logistics Management*, Vol. 24, No. 7, pp. 35-47.
[20] Mentzer et al. (2001). "Defining Supply Chain Management", *Journal of Business Logistics,* Vol 22, N 2.

particular supply chain, may feed into a number of different supply chains, forming *supply networks,* where several supply chains may cross through an individual operation[21] (Box 4).

Box 4. Selected definitions of 'supply chain'

Narrow definition	Broad definition
"The supply chain **links many companies together**, starting with unprocessed raw materials and ending with the final customer using the finished goods" (CSCMP, 2017)	"**The network** of activities that delivers a finished product or service to the customer" (Reid and Sanders, 2013) "**Link or strand of operations** that provides goods and services through to end-customers" (Slack et al, 2013)

… while definitions of 'value chain' tend to focus on processes of value addition, often with an emphasis on those that underpin the competitive advantage of firms and industries.

In its basic form, a 'value chain' is described as the "process or activities by which a single company adds value to an article, including production, marketing, and the provision of after-sales service"[22]. The concept of a value chain was popularised by Michael Porter[23], who describes it as the "activities within and around an organisation that gives it the ability to create value that exceeds the cost of providing goods or services to clients". These include firm-level activities, such as inbound logistics, operations, outbound logistics, marketing and sales, after-sale services, procurement, human resources, technological development, and infrastructure.

Broader definitions of a 'value chain' have shifted the focus away from the firm, to the interconnected set of firms and wider activities that together create the value added of the product[24]. These firms and activities may be found both upstream and downstream of factory-based activities at the firm level, and include research and development, and design and supply management[25]. From these perspectives, value chains are seen as "mechanisms that allow producers, processors, buyers, sellers, and consumers — separated by time and space — to gradually add value to products and services as they pass from one link in the chain to the next" [26]. Such definitions tend to emphasise differences in the levels of 'value' that different activities and firms create and capture, as well as the different mechanisms through which firms 'upgrade' to capture increased levels of value[27].

Furthermore, broad definitions of value chains have stressed the role of "networks" of firms (i.e. *value chain networks*), and the role that multiple firms of different fields of expertise (e.g. technology, financial, marketing, quality control) possibly located in different locations, have in delivering a finished product or service to customers. Further, some authors have also emphasised

[21] Slack et al. (2013). Operations Managements. 7th edition. Pearson.
[22] Oxford Dictionary (2017). Value Chain.
[23] Porter (1985). Competitive Advantage. Creating and Sustaining Superior Performance. The Free Press.
[24] UNIDO (2009). "Value Chain Diagnostics for Industrial Development. Building blocks for a holistic and rapid analytical tool". UNIDO Working Paper. United Nations Industrial Development Organization.
[25] UNIDO (2009).
[26] Ibid.
[27] Kaplinsky and Morris (2000). A Handbook for Value Chain Research. Prepared for the IDRC.

the existence of a system of governance and "dominating actors" that dictate how value is distributed among actors (Box 5).

Box 5. Selected definitions of 'value chain'

Narrow definition – Firm focus	Broad definition – Network focus
▪ The value chain describes the activities the organisation performs and links them to its **competitive position** ▪ Value chain analysis describes the **activities within and around an organisation**, evaluating which value each particular activity adds to products or services	▪ "Set of **businesses, activities and relationships** engaged in creating a final product (or service)" (UNIDO, 2009) ▪ "Analysis of **networks of functionally interrelated producers and buyers** engaged on a global scale in processes of value creation as products pass across borders and between different actors in the chain" (UNIDO, 2009)

As industries become more geographically dispersed, the concept of the 'global value chain' has gained relevance

Narrow definitions of both supply and value chain mainly focus on the domestic market rather than on globally distributed activities. Reduction in transportation and information costs has contributed to the factories "unbundling"[28], and made it economically feasible to have manufacturing stages that are geographically separated. Therefore, production stages have become increasingly spread over different locations, beyond the domestic borders, and firms have changed their organisational model from vertical to horizontal integration.

As a result, some definitions of the value chain emphasise how the creation of value embedded in final products may be distributed across different continents, in so-called 'global value chains'. This includes the total chain of value-adding activities involved in delivering products and services, including all contributing firms distributed around the world.

The term "industrial commons" describes a common set of suppliers and human resources that provide a shared benefit to multiple companies

Box 6. Industrial commons

'Industrial commons' refers to a common set of suppliers and human resources that enable innovation and competitiveness across multiple firms. Industrial commons can include:

- **Suppliers and human resources**
- **R&D know-how**
- **Advanced process development and engineering skills**
- **Manufacturing competencies related to a specific technology**

The term 'industrial commons' has become increasingly influential in the international policy debate. It describes a common set of suppliers and human resources available to manufacturing firms in a given region, including: R&D know-how; advanced process development and engineering skills; and manufacturing competencies related to a specific technology.

These industrial resources provide a shared benefit to multiple companies and provide a foundation for innovation and competitiveness[29]. The concept of industrial commons emphasises that despite the global nature of modern

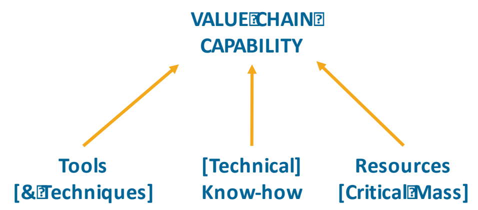
[28] Baldwin (2011). "Trade and Industrialisation after Globalisation's 2nd Unbundling: How Building and Joining a Supply Chain are Different and why it Matters". *NBER Working Paper 17716*. National Bureau of Economic Research.
[29] Pisano and Shih (2009) "Restoring American Competitiveness". Harvard Business Review. July-August Issue. Pisano and Shih (2012). Producing Prosperity. Why America needs a Manufacturing Renaissance. Harvard Business Review Press.

industries, the geographical proximity, of this set of suppliers and human resources, has a key role to play in fostering technological and industrial innovation.

"Value chain capabilities" refer to the ability to exploit value capture opportunities by delivering products and services demanded by customers at the right specifications

The basic concept of a capability is the "power or ability to do something"[30]. From a policy perspective, the concept of "value chain capabilities" can be useful to frame the focus of interventions aimed at supporting innovation and competitiveness. Value chain capabilities can be defined as "the ability to respond to customer requirements, competiveness challenges, value capture opportunities; the ability to deliver products and services with certain competitive qualities / characteristics / functionalities"[31].

Box 5. Simplified representation of value chain capabilities



Capabilities are underpinned by competencies. These refer to tools, techniques or know-how (whether technical or operational) which – when combined with other competencies and resources – can underpin (one or more) capabilities.

There are a range of distinct technical competency types associated with different types of technology, which might have different levels of 'public good' and, hence, entail different roles for government.

Relevant technical competencies underpinning value chain capabilities include:

- Production technology competencies
- Enabling technology competencies (e.g. measuring, characterising, testing technologies; advanced materials design/development competencies; ICT, modelling/simulation)
- Product technology competencies (i.e. related to the technologies delivering core application technology functionalities)
- Scientific / applied science domain-related competencies
- Management/operational competences
- System engineering/integration competencies
- Etc.

Policy action, required for addressing opportunities and challenges to industries' and firms' ability to create and capture value, might be framed in terms of some or all of the following:

- new/enhanced capabilities (to meet opportunities and challenges)
- new/enhanced manufacturing competencies (to create the capabilities)
- new/enhanced action(s) by one or more institutional actor(s) to deliver on value potential

[30] Oxford Dictionary (2017). Capability.
[31] IfM (2016). High Value Manufacturing Landscape. Institute for Manufacturing. University of Cambridge.

Effective policy design requires recognition of the increasing complexity of industries and the capabilities underpinning value creation and capture

In conclusion, the definitions used to characterise modern industries are diverse and have evolved over time. A common feature in recent definitions is the increased recognition of the systems nature of global industries, and its key elements and sub-systems. **Recent definitions of manufacturing, for instance, go beyond the simple production process to comprise the full cycle of activities from research and development, through design, logistics, services and end of life management.** Furthermore, modern industries are increasingly represented as being integrated into global chains of knowledge and production.

From a policy perspective, the **discussion above implies that interventions are required to be based on a systemic approach, taking account of the whole value chain (or global value chain), rather than being bound by specific segments of it.** In particular, interventions need to go beyond a focus on large companies' current business needs, and their immediate supply chains, if they are to be successful in supporting industrial innovation and competitiveness. This is because there is a wider range of firms and capabilities underpinning the current performance and future innovation potential, not only of individual sectors, but also of the country as a whole. **Similarly, policy programmes need to consider a wider set of institutions that might not be directly involved with productive processes, such as public and/or private research centres, professional training organisations, as well as industry associations.**

In partnership with the private sector, governments can co-invest to strengthen a common set of suppliers and human resources - the *industrial commons* - enabling innovation and competitiveness across multiple firms. Manufacturing programmes, focused on these *industrial commons,* can target, for example, an enhancement of R&D know-how, advanced process and engineering skills development, as well as the development of manufacturing competencies related to specific technologies[32].

Finally, the concept of 'value chain capabilities' can help characterise the role of supplier firms in underpinning industrial competitiveness and innovation, and frame the policy efforts aimed at supporting them. Policy efforts might be required to address market and system failures, constraining value chain actors from pursuing specific value capture opportunities. Different efforts might be required depending on the nature of these failures, and the way in which they are implemented might be dictated by local institutional contexts. In this context, the international review of policy efforts, presented in the next section, illustrate the variety of actions, institutions and levels of funding that have been deployed to support value chain capability development internationally.

[32] Tassey, G. (2010). Rationales and mechanisms for revitalizing US manufacturing R&D strategies, Journal of Technology Transfer.

3

Opportunity areas for strengthening UK value chain capabilities

This section describes four opportunity areas for strengthening value chain capabilities that have been identified as being of particular relevance to UK industries. These areas have been defined in consultation with the Department for Business, Energy & Industrial Strategy (BEIS).

While some overlap exists, this simplified categorisation has proved useful to distinguish different policy missions, and to structure the review of international approaches presented in Section 4. For instance, in order to target domestic supply opportunities (opportunity area 1), some programmes may place emphasis on promoting R&D among SMEs in the value chain (opportunity area 4). Additionally, it is useful to distinguish between programmes with a specific supply chain development goal, and those with a more generic goal of R&D promotion, regardless of whether firms intend to form new supply relationships or not. Similarly, programmes, focused on the development of value chains of the future, are likely to involve interventions promoting R&D, but their goal is more specific (related to particular sectors and technologies) than R&D promotion across the board.

Opportunity areas for strengthening UK value chain capabilities

1. **Exploiting domestic supply opportunities**
   – value capture from efficiency gains & improved trade balance
2. **Technology diffusion along value chains**
   – value capture from improved productivity & competitiveness
3. **Promoting R&D among SMEs in the value chain**
   – value capture from a more inclusive national innovation system
4. **Enabling development of the value chains of the future**
   – value capture from industrialisation of emerging technologies

1. Exploiting domestic supply opportunities
value capture from efficiency gains & improved trade balance

The capability challenge

- In many industries, the ability to compete internationally depends on the availability and quality of local suppliers. But despite the benefits that higher domestic sourcing would generate in a number of sectors, UK supply chains remain relatively weak. For instance, only around 40% of the parts used in vehicles assembled in the UK are sourced domestically[33]. Overall, around half of manufactured parts used in the UK are sourced domestically, compared with 90% in services[34].
- Low UK content in a number of sectors has contributed to a long-run trade deficit which, despite a remarkable increase of service exports over the last few years, still stands at around £30bn[35].
- From a national economy perspective, the fact that firms are not able to find competent suppliers in the UK indicates weaknesses in the industrial commons and/or the linkages within them.
- Furthermore, low levels of domestic sourcing of intermediaries also represent potential supply risks, not least in the context of Brexit.

The opportunity

- Access to competent local suppliers allows firms to be more responsive to market demand fluctuations, share resources, enhance collaborations, and reduce inventories. Current suppliers also represent a platform for the industries and value chains of the future.
- The availability of local suppliers can also help reduce the total delivered cost, the overall carbon footprint of the industry, and the risks associated with disruptions, such as foreign natural disasters.
- In the automotive industry, for example, leaner and more flexible operations are possible when suppliers are located close to the vehicle manufacturing plant. This is particularly important in some premium segments where UK firms operate[36].
- Opportunities for UK suppliers have been identified in a number of industries, including: £4bn potential extra sourcing opportunities in automotive and £4.7bn in nuclear new build [37].

Rationale for intervention

- **Information failures:** Large primes are often unaware of the existence of firms that might be able to supply parts, components and services from within the country[38]. At the same time, suppliers are often unaware of potential domestic clients[39]. Government intervention might be required to increase awareness of opportunities and address such information failures.
- **Network failures:** Because of existing business arrangements, firms might be 'locked-in' to certain client and supplier types. Government intervention might help address such lock-ins, and/or path dependencies, by helping suppliers identify business opportunities in other sectors, and by supporting the development of capabilities needed to address them.
- **Public good:** The lack of suppliers of critical technologies and capabilities might hinder innovation and value capture. There is a public good element in intervention aimed at building these capabilities within the industrial commons

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[38] Ibid.
[39] Ibid.

2. Technology diffusion along value chains

value capture from increased technological sophistication

The capability challenge

- Due to weak 'absorptive capacity'[40], many firms, in particular SMEs, fail to exploit opportunities offered by technologies available in the market to update products and processes[41].
- In the UK, low levels of investment in capital equipment may have hindered the adoption of process improvements and new technologies[42].
- Of particular concern is the need for new technology adoption in addressing large productivity disparities between "the best and the rest"[43]. According to the Bank of England[44]:
    - Around one-third of UK firms have experienced no productivity increase since 2000
    - For every frontier firm, there are two or three firms pushing down the average
- In many cases, large firms might underinvest in their supply chains due to the fear of helping competitors[45].

The opportunity

- Larger firms, with higher levels of technological sophistication and financial resources, have a role to play in, and can benefit from, supporting technology adoption across their supply chains. New technology adoption is critical to address the long tail of unproductive firms hindering national industrial competitiveness.
- There are opportunities for UK firms to exploit new possibilities offered by developments in the physical and biological sciences[46].
- In the context of rapid technological change, regions and countries with higher rates of new technology adoption are likely to become more attractive industrial locations[47].

Rationale for intervention

- **Information failures:** Specialised technical and market knowledge is costly and, as a result, not all firms have the basis for making informed technology investment decisions. The potential of new technology adoption is often unknown, particularly when relevant technologies have originated in other sectors. Government-supported initiatives can play a key role in providing information about particular technologies, whose benefits have already been proven in the market place (e.g. quality management systems, energy-saving technologies, productivity-enhancing digital tools).
- **Network failures:** Underinvestment in suppliers, for fear of helping competitors, might hinder the innovative potential of the country as a whole. Government action might encourage the formation of industry networks to share best practices in technology diffusion among business partners.

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[40] Absorptive capacity is defined by Cohen and Levinthal (1990) as "the ability to recognize the value of new information, assimilate it, and apply it to commercial ends." This capacity is largely a function of the firm's level of prior related knowledge, and it is considered critical to its innovative capabilities.
[41] Cohen W.M., Levinthal D.A. (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation". Administrative Science Quarterly, Vol. 35, No. 1, Special Issue: Technology, Organizations, and Innovation pp. 128-152.
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[45] HMG (2015). Strengthening UK manufacturing supply chains. An action plan for government and industry.
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[47] O'Sullivan, E. and López-Gómez, C. (2017). Manufacturing R&D Policies for the Next Production Revolution: An International Review of Emerging Research Priorities and Policy Approaches. In OECD (2017), The Next Production Revolution: Implications for Governments and Business, OECD Publishing, Paris.

3. Promoting R&D among SMEs in the value chain
value capture from a more inclusive national innovation system

The capability challenge

- Not all firms have the capabilities to fully engage in, and benefit from, the national innovation system. In particular, SMEs are not often engaged in innovative activities, and have a low contribution to manufacturing R&D. In the US, for example, it is estimated that only around 2% of small firms conduct R&D, compared to 14% of large firms[48]. Overall, over 300,000 small and mid-sized firms are believed to be "largely outside the U.S. innovation system"[49].
- SMEs' low absorptive capacity hinder their ability to update production processes and undertake the development of new products: the smaller the company is, the harder it is to innovate or capitalise on its innovations[50].
- A large proportion of SMEs do not have the time, capacity or funds to partner with universities or research and technology organisations. SMEs also have an intrinsic "innovation fear", as an unsuccessful investment of their limited resources, in an innovative project, can greatly affect their financial performance and even jeopardise their survival.
- The lack of involvement in R&D and innovative activities represents a risk to long-term competitiveness in advanced industries that require continuous innovation.

The opportunity

- Increased SME engagement in business R&D has the potential to increase the country's gross domestic expenditure on R&D (GERD), which is a key policy target in many countries.
- Engagement in R&D can help SMEs increase their resilience. New know-how, developed through R&D, can help them reconfigure capabilities, and respond to more stringent customer requirements. Further, knowledge-intensive suppliers tend to be more difficult to replace.
- R&D partnerships involving SMEs can be sources of new ideas and breakthroughs for their clients. The creativity and agility of small, research-intensive manufacturers can be a source of innovation for the larger companies they supply[51].
- State-of-the-art research, engineering expertise, and equipment available in a number of UK institutions, not necessarily available in other competitor countries, might provide UK manufacturing firms with a head start in their efforts to engage in R&D and innovation.

Rationale for intervention

- **Information failures:** Firms might lack information about the potential benefits of technology development activities. Government action might be required to showcase the potential of new technologies through demonstrators, case studies, and related initiatives.
- **Coordination failure:** Because industries are interdependent, it might be necessary for the government to bring together R&D investments and innovation efforts that benefit multiple industries for the purpose of economy-wide productivity growth.
- **Public good**: Firms tend to underinvest on R&D because some forms of technological knowledge cannot be patented, and thus might be exploited by others. Knowledge and skills, generated through R&D, might also benefit others if workers decide to move to a new employer.

[48] PCAST(2015). Supply Chain Innovation: Strengthening America's Small Manufacturers.
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4. Enabling development of the value chains of the future

value capture from industrialisation of emerging technologies

The capability challenge

- The development of new value chains for next-generation technologies, products and industries require reconfigurable value chain capabilities[52]. Research suggests that without a number of cross-cutting industrial commons, countries lose the ability to innovate in next-generation products and services, with local technologies often taken overseas for industrialisation[53].
- The hollowing out of the UK industrial base over the last years represents a potential constraint to the industrialisation of emerging technologies. For example, concerns have been raised about the risk that some automotive technologies developed in the UK might be taken abroad for industrialisation[54].
- Research in the US suggests that decades of outsourcing of manufacturing activities have undermined the ability to innovate in next-generation technologies, products and industries[55].

The opportunity

- Opportunities exist to develop domestic value chains in strategically important emerging technologies & sectors where the UK has a leading science base, such as quantum, synthetic biology, biopharma, etc. It is estimated, for example, that 30,000 new potential jobs could be generated in the offshore wind supply chain by 2020.
- Given the UK R&D strengths, opportunities exist to exploit gains from manufacturing co-locations, as evidence suggests that R&D activity stimulates further manufacturing growth and scope. While supply chains for new technologies do not yet exist, and new firms might need to emerge, current capabilities might be repurposed to support industrialisation of emerging technologies.
- Rebuilding cross-cutting capabilities – the ‘industrial commons’ – supporting UK manufacturing industries can enable the scale-up of next-generation products and services. These ‘commons’ represent “a platform for innovation and entrepreneurship”[56].

Rationale for intervention

- **Coordination failures:** Modern industrial challenges are often large-scale and multi-disciplinary, and cannot be tackled by single firms. Alignment of R&D investments, between related fields of expertise, might be necessary to tackle such ‘grand challenges’. In theory, this could happen through private contracting, but high transactions costs and the uncertainty of the market potential might inhibit collaboration.
- **Network failures:** In some cases, firms find themselves unable to transition into new technologies or businesses. For example, in the low-carbon automotive market, producers might face, on the one hand, the institutional lock-in of the automotive sector, but on the other hand, they may also need to access electric battery and fuel cell technologies that lie outside the scope of traditional automotive markets. Government initiatives might help address such technology lock-ins and/or path dependencies.

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4

Case studies

This section presents reviews of a selection of programmes and initiatives in major industrial countries, addressing the opportunity areas for strengthening UK value chain capabilities, identified in Section 3 (exploiting supply chain opportunities; promoting technology diffusion along value chains; promoting R&D among SMEs in the value chain; and enabling the development of the value chains of the future).

Many of the cases, selected for review in this section, are described as national flagship programmes and initiatives; and therefore, provide representative insights into international policy efforts. The full list of case studies identified is presented in **Appendix 2**.

Overall, programmes and initiatives from the following countries/regions were included in this review:

- Canada
- European Union
- Germany
- Japan
- Taiwan
- Singapore
- Sweden
- United States

As noted earlier, the focus of the review has been on industrial capability building. The review does not include, purely financial incentives or generic tax incentives that apply to all firms in the economy; generic export promotion or overseas business development programmes; generic FDI promotion programmes; or start-up promotion programmes/university accelerators.

The cases described in this section are summarised in Table 1.

Challenge & Opportunities Emphasised	Selected Cases Illustrating Diversity of International Approaches
'Exploiting Domestic Supply Opportunities'	**4.1** Supplier Development Initiative (SDI), EDB/SIMTech (Singapore) **4.2** Supplier Scouting and Business-to-Business Networks (US) **4.3** Industrial Technology Research Institute, ITRI (Taiwan)
'Technology Diffusion along Value Chains'	**4.4** Hollings Manufacturing Extension Partnership (US) **4.5** Industrial Value Chain initiative, IVI (Japan) **4.6** Industry 4.0 Transfer Projects at IT'S OWL Cluster Initiative (Germany)
'Promoting R&D among SMEs in the Value Chains'	**4.7** German Federation of Industrial Research Associations, AiF (Germany) **4.8** Cooperation Projects & Networks, Central Innovation Program for SMEs (ZIM) / Germany-Singapore SME Funding Programme **4.9** New Mexico Small Business Assistance (NMSBA) Program (US)
'Enabling Development of Value Chains of the Future'	**4.10** Small Business Innovation Research (SBIR, US) **4.11** Manufacturing USA institutes (US) **4.12** Precision Engineering Centre of Innovation, SIMTech (Singapore) **4.13** Impulsing Paradigm Change through Disruptive Technologies Program, ImPACT (Japan)

Table 1: Summary of case studies

Notes:

- It is worth noting that some cases focus on specific activities, or are programmes focused on value chain capability development that might be part of larger initiatives/institutions. For example, discussions are presented of specific initiatives at the Singapore Institute for Manufacturing Technologies (SIMTech), rather than describing the activities of the institute as a whole.
- Where possible, information about evaluation/impact assessments is presented. However, some of the programmes and initiatives reviewed have only emerged in the last few years and have not yet been formally evaluated, or the evaluation results are not in the public domain. Further work is required to analyse the success metrics for value chain capability development programmes and to develop appropriate systemic evaluation processes.
- The qualitative assessment, and summaries presented for each case study (including the why-what-how matrix), is based on the literature review, benchmarking, interviews and expert judgement.

EXPLOITING DOMESTIC SUPPLY OPPORTUNITIES

4.1 Supplier Development Initiative (SDI), EDB/SIMTech (Singapore)

4.2 Supplier Scouting and Business-to-Business Networks (US)

4.3 Industrial Technology Research Institute, ITRI (Taiwan)

4.1

Supplier Development Initiative (SDI), Singapore Institute of Manufacturing Technology (SIMTech) – Singapore

The Precision Engineering Centre of Innovation (PE COI) at the Singapore Institute of Manufacturing Technologies (SIMTech) focuses on the advancement of precision engineering competencies, considered to be the 'backbone' of manufacturing industries. The initiative aims to leverage a pool of 2,700 identified companies that provide components, systems and engineering services to exploit domestic supply opportunities.

The Centre's Supplier Development Initiative (SDI) provides technical manpower, equipment and facilities to help companies venture into 'high growth' industries. The initiative supports large firms in sectors, such as semiconductor equipment, aerospace, medical technology and electronics, to help them develop local supply chains in Singapore. So while the pool of companies, the initiative works with, comes from a variety of sectors and subsectors, support is purposely directed at addressing the capability gaps in selected sectoral value chains.

Under SDI, SMEs collaborate with large firms on areas of capability development and the co-development of new products. The government funds up to 70% of eligible costs in such collaborative projects.

A distinctive feature of the initiative is the high level of integration between SIMTech and other government agencies, to ensure that sufficient information is gathered regarding the supply chain needs of large firms recently established in the country. Such agencies include the Economic Development Board (EDB, in charge of FDI and export promotion), SPRING (the enterprise development agency), and JTC (the country's principal developer and manager of industrial estates). By joining up the services of these and other agencies, corporations receive bespoke and co-ordinated support, to ensure that local suppliers (primarily SMEs) develop the capabilities required to supply multinationals at the specifications and scale required. Multinational local sourcing needs also inform the country's FDI attraction strategy.

Programme Overview | Supplier Development Initiative, SIMTech

Missions

The Supplier Development Initiative (SDI) aims to enhance the capabilities of supplier companies of the Precision Engineering (PE) sector, and link them to larger manufacturing firms across a broad range of industry clusters[1].

Focus areas

The precision engineering sector includes firms (primarily SMEs) involved in the design and assembly of machinery & systems, and the production of precision modules & components. SDI supports capability development activities for SME adoption of new processes or materials.

Priority sectors for SDI include: Aerospace, MedTech Initiative, Oil and Gas, Complex Equipment, Metal industry, Polymer Industry, Engineering Design, Simulation and Proto-typing[2].

Programmes/activities

Capability development activities supported by SDI include:

- *Partnerships for Capability Transformation (PACT) initiative*: Collaborative projects between large manufacturers and local SMEs:
  - Knowledge transfer from a large firm to at least one SME.
  - Capability upgrading of a large firm's new or existing suppliers.
  - Development and test-bedding of innovative solutions between a large firm and at least one SME[3].
- *Capability Development Grant (CDG):* Support to scale up SMEs' capabilities and ensure business sustainability. Projects are in areas such as product development, human capital development, business processes enhancements for productivity and business model transformation[4].

Example Services

- Material, Process and Product Innovation
- Business Model and Operations Innovation
- Overseas mission trip, roundtable and networking
- Specialist skills training: Precision Engineering (PE), Workforce Skills Qualifications (WSQ), Specialist and Graduate Diploma courses
- Expert advice on process and automation technologies
- Advisory support and consultancy
- Sharing of resources

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	○	●
	Coordination failures	○	●	○
	Network failures	○	○	●
	Public good	●	○	○
WHAT Intended change in the system	New technology adoption	○	○	●
	New market orientation	○	○	●
	New firm formation	●	○	○
	Industrial dialogue / best-practice sharing	○	○	●
	FDI attraction	○	●	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	●	○
	Knowledge diffusion (linkages & institutions)**	○	○	●
	Knowledge use (firm capability)***	○	○	●

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Budget (indicative)

- PACT received S$ 205 million (~£113 million) between 2010 and 2015[1].
- In 2015, 1,300 enterprises tapped into the Capability Development Grant, which represent 14.9% of manufacturing SMES[5,6].
- SMEs collaborate with large firms on areas of capability development and co-development of new products. The government funds up to 70% of eligible costs.
- In 2015, 20 Partnerships for Capability Transformation (PACT) projects were facilitated between 16 large organisations and 200 SMEs[5]. 70% funding support for qualifying development costs[3,4].

Impact

Success case studies report increase in sales turnover, increase in annual revenue, improved operational efficiency, improved productivity, quality improvement in products and services, access to new markets, among other results[7].

Sources

[1] EDB (ND). Precision Engineering. EDB Fact Sheet.
[2] SIMTech (2014). Precision Engineering Centre of Innovation. Centre flier.
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4.2

Supplier Scouting and Business-to-Business Networks – United States

The Supplier Scouting programme and the Business-to-Business Networks are programmes aimed at helping manufacturers find U.S. suppliers with the right capabilities to meet their supply chain needs. Both programmes are part of the Manufacturing Extension Partnership (MEP, see section **4.4**) and work through MEP's network of 30,000 manufacturers.

In particular, Supplier Scouting has helped agencies locate suppliers with specific demographic attributes, such as veteran-owned or service disabled veteran-owned small businesses. The project focuses on addressing specific supply gaps rather than on productivity or competitiveness issues.

Supplier Scouting has established a number of partnerships with federal agencies, including:

- U.S. Department of Transportation
- U.S. Department of Energy
- U.S. Department of Commerce
- U.S. Department of Defense

The Business-to-Business Networks are projects of online regional business-to-business networks to support market matching within 10 MEP centres.

Programme Overview | Supplier Scouting and Business-to-Business Networks

Mission

Identify manufacturing local SMEs with specific technical capabilities and production capacities that match particular supply chain needs of large companies and government agencies[1].

Focus

Sectors supported by Supplier Scouting[2]:

- Passenger and freight rail cars and rail locomotives.
- Railroad track and physical infrastructure.
- Highway and waterborne transportation systems.
- Defense weapon systems and defense support equipment.
- Energy-related products.
- Laboratory instruments.
- Various consumer products.
- Power utilities.

Budget and priorities

- $2.5 million in grants to 10 Hollings Manufacturing Extension Partnership (MEP) centres to develop, deploy and maintain online regional business-to-business network projects.
- Each awardee received a total of $250,000 for a project up to two years (cost sharing not required)[3].
- The intention of the funding is not to develop new infrastructure, but rather use existing technologies[4]. The funded projects address the following priorities:
  - Create jobs or train newly hired employees;
  - Promote technology transfer and commercialisation of environmentally focused materials, products, and processes;
  - Increase energy efficiency; and
  - Improve the competitiveness of industries in the region in which the Centre or Centres are located[4].

Programmes/activities

Three examples of the business-to-business networks projects:

- *Georgia Tech Research Corporation - GA MEP (Atlanta, Ga.).* This project aims to build a model with a platform database solution powered by human input and matchmaking, and includes supply chain partners, technology solutions and workforce enhancement. The project focuses on the Southeastern automobile supplier and technology network within the states of Mississippi, Tennessee, Alabama, South Carolina and Georgia.

			Minor emphasis	Some emphasis	Primary emphasis
WHY	Rationale for intervention	Information failures	○	○	●
		Coordination failures	○	●	○
		Network failures	○	○	●
		Public good	●	○	○
WHAT	Intended change in the system	New technology adoption	●	○	○
		New market orientation	●	○	○
		New firm formation	●	○	○
		Industrial dialogue / best-practice sharing	○	○	●
		FDI attraction	●	○	○
HOW	Interventions funded by programme	Knowledge generation (basic and applied R&D)*	●	○	○
		Knowledge diffusion (linkages & institutions)**	○	○	●
		Knowledge use (firm capability)***	○	●	○

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

- *California Manufacturing Technology Consultants - CMTC (Torrance, Calif.)*. This project involves an e-commerce partnership that will be designed to match domestic and international business opportunities and technologies with small and medium-size manufacturers in California.

- *Boise State University - Idaho TechHelp (Boise, Idaho).* This project aims to develop and improve electronic tools and real-time, human-to-human services, to provide a coordinated and timely business opportunity, technology, supplier and marketing scouting. Its focus is on addressing the specific growth needs of the aerospace and metal fabrication manufacturer clusters of rural Idaho[1].

Impact

Supplier scouting:

- Over $108 million new business opportunities.
- 184 items scouted.
- 70+ identified suppliers.
- 15 participating organisations[1].

Sources

[1] MP (ND). MEP Supplier Scouting.
[2] NIST (2016). Buy America Transit Supply Chain Connectivity Forum.
[3] NIST (2014). NIST Awards $2.5 Million in Grants to MEP Centers for Pilot Business-to-Business Networks.
[4] NIST (2014). Announcement Of Federal Funding Opportunity (FFO) Business-to-Business Network Pilots.
[5] The Executive Office of the President and the U.S. Department of Commerce (2015) Supply chain innovation: Strengthening America's Small Manufacturers.

4.3

Industrial Technology Research Institute, ITRI – Taiwan

The Industrial Technology Research Institute (ITRI) is a non-profit R&D organisation, founded in 1973, with the aim to develop a semiconductor industry in Taiwan. Since its establishment, the ITRI has contributed to the development of supply chains, not only in semiconductors but also in other industries, such as photovoltaic and biotechnology.

The ITRI works as a "technology intermediary", having as a main function the transfer and diffusion of technology from domestic and overseas laboratories to domestic companies in selected sectors.

Some of the services that the ITRI provides are: contract research; product and process development; pilot production and scale-up; testing and certification; and business consultancy. The government typically provides half of the budget for the ITRI's operations, which is then matched by income from the private sector.

The ITRI has a presence worldwide with offices in Silicon Valley, Tokyo, Berlin, Moscow and Eindhoven. In recent years the ITRI has strengthened its collaboration with the European Union. For example, the ITRI is participating in the EU's H2020 NoAgroWaste initiative, enabling Taiwan to become a link in the EU's biomaterials supply chain.

Programme Overview | Industrial Technology Research Institute, ITRI

Mission

The Industrial Technology Research Institute (ITRI) aims to contribute to the development and strengthening of industrial value chains through applied research and technological services, including design, materials, equipment, testing, packaging and quality control[1,2].

Focus areas

Three application domains:

- Smart Living: Smart Endpoints; Mechanical Systems Technologies; Cloud Service and Big Data Technology; Infrastructure and Service Platform.
- Quality Health: Medical Devices; Technologies for Healthcare; Biomedical Technologies.
- Sustainable Environment: Energy Technologies; Environment Technologies; Energy Conservation Technologies[1].

Budget

- ITRI's budget is about $600 million per year, half of which is provided by the government and half by the private sector[2].
-

Programmes and activities

The ITRI laboratories develop and test prototype products, production equipment and materials, and experiment with new applications. When the laboratories seek to spin off a promising technology, the ITRI's venture capital subsidiary, the Industrial Technology Investment Corporation (ITIC), assesses the commercial potential and sizes up the business prospects for the new venture. The ITRI's technology integration centres also play a key role in this process[2].

Example Services

- Open Lab and incubator.
- Contract research.
- Product and process development.
- Pilot production and scale-up.
- Testing and certification.
- Licensing.
- Patent auctions.
- Spinoffs.
- Research consortia and alliances.
- Education and training[1].

Impact

- The ITRI has incubated more than 240 startups and spinoffs[3].
- Industry services per year: 15,351 (2015)[3].
- Transferred technologies per year: 642 (2015)[3].
- Accumulated patents: 25,204 (2016)[3].

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	○	●
	Coordination failures	○	○	●
	Network failures	○	○	●
	Public good	●	○	○
WHAT Intended change in the system	New technology adoption	○	○	●
	New market orientation	○	○	●
	New firm formation	○	●	○
	Industrial dialogue / best-practice sharing	○	○	●
	FDI attraction	○	●	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	○	●	○
	Knowledge use (firm capability)***	○	○	●

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

In 2016 the ITRI facilitated:

- Establishment of 10 startups.
- Over NT$ 30 billion (~£737 million) of investment from enterprises.
- NT$6 million (~£148 million) net income.
- 1,573 granted patents (98.1% invention and 1.8% utility model patents).
- Over 50 technology projects for public welfare[4].

Success stories

Photovoltaic solar equipment industry.

In 1988, Taiwan's first solar cell company was established, Sinonar Amorphous Company, using technology developed by the ITRI and founded by two former ITRI staffers. Between 1984 and 2008 the ITRI had secured or was pursuing applications for 1,940 patents in solar cell technology.

Taiwan's semiconductor manufacturers, including two ITRI spinoffs, have played a significant role in the development of Taiwan's thin film solar cell industry.

In 2007, the ITRI decided to release 233 patents in the fields of solar energy and energy storage and efficiency to local Taiwanese companies. Preleased to support the upgrading of local technology and assist industries to expand their global market share[2].

Sources

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TECHNOLOGY DIFFUSION ALONG MANUFACTURING VALUE CHAINS

4.4

Hollings Manufacturing Extension Partnership (MEP) – United States

The Hollings Manufacturing Extension Partnership (MEP) network provides technical expertise to small manufacturers, strengthens capabilities across supply chains, and promotes collaboration between suppliers. MEP has nearly 600 offices and Centres located in all 50 US states and in Puerto Rico.

MEP network works cooperatively with accredited organisations that include non-profit, state government agencies, and universities. More than 1,200 experts work with manufacturers to help them improve their processes and identify opportunities to adopt new technologies or take new products to market. Around 30,000 manufacturers were served by the MEP in the Fiscal Year 2015. MEP's services include: Supplier Improvement and Supply Chain Optimization, Supplier Scouting and Business-to-Business Networks, and Supply Chain Technology Acceleration.

This initiative indeed focuses on addressing cross-sectoral manufacturing capabilities without a particular sector focus.

The MEP is a successor of the Manufacturing Technology Centers Program, developed in 1989, as a response to the perceived decline in the position of the United States in comparison to Japan. The MEP is a part of the National Institute of Standards and Technology (NIST).

Programme Overview | Hollings Manufacturing Extension Partnership (MEP)

Mission

Enhance the productivity and technological performance of manufacturer SMEs through technology transfer[1].

Budget

- The budget of the MEP was $130 million for Fiscal Share 2016, with Cost Share Requirements for Centers[3].
- In 2015 the national network of MEP Centers interacted with 29,101 manufacturers to improve their performance, which represent 11.7% of the U.S. manufacturer SMEs[3,4].

Example Services

- Product development and prototyping.
- Lean and process improvements.
- Workforce development.
- Supply chain development.
- Technology scouting and transfer[4].

Coverage

The MEP has nearly 600 offices and Centres located in all 50 US states and in Puerto Rico.

Governance

The MEP is organised into headquarters, regional offices, and partners, including the MEP centres. There is also a national advisory board that provides strategic advice, but is not operationally integrated into the MEP.

The headquarters staff includes a director and deputy director, as well as senior staff responsible for system operations, program development, centre operations, communications, strategic partnerships, and manufacturing policy and research.

Partners

- State and local governments
- Federal government agencies, departments, programs and laboratories
- Universities, community colleges and technical schools
- Trade associations
- Professional societies
- Industry leaders and think tanks
- Economic development organisations

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	○	●
	Coordination failures	○	●	○
	Network failures	○	○	●
	Public good	○	●	○
WHAT Intended change in the system	New technology adoption	○	○	●
	New market orientation	○	○	●
	New firm formation	○	●	○
	Industrial dialogue / best-practice sharing	○	●	○
	FDI attraction	●	○	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	●	○	○
	Knowledge diffusion (linkages & institutions)**	○	●	○
	Knowledge use (firm capability)***	○	○	●

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Impact

- In the Fiscal Year 2016, the MEP claims to have supported:
  - $9.3 billion in sales.
  - $3.5 billion in total investment in U.S. manufacturing.
  - $1.4 billion in savings,
  - 86,602 jobs[6].
- For every one dollar of federal investment, the MEP national network estimates that $17.9 is generated in new sales growth for manufacturers and $27.0 in new client investment. This translates into $2.3 billion in new sales annually[2].
- For every $1,501 of federal investment, the MEP estimates that one manufacturing job is created or retained[2].

Sources

[1] National Academy of Science (2013). 21st Century Manufacturing. The Role of the Manufacturing Extension Partnership Program. The National Academies Press.
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[6] NIST – MEP (2017). Impacts.
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4.5

Industrial Value Chain initiative (IVI) – Japan

The IVI is a collaborative forum that promotes the development and adoption of 'smart manufacturing' solutions. As part of the initiative, large and small firms come together to develop 'smart manufacturing scenarios', which describe ways in which the combination of manufacturing and ICT technologies can lead to improvements in common industrial operations (both within a firm and between firms in the value chain).

These scenarios are developed bottom-up based on Japanese concepts of continuous improvement, with a common aim of 'creating value from data'. Solutions are then made available to members of the initiative, with advice available to help SMEs on how they might adapt them to their particular operations. The initiative focuses on specific capability development in the field of digital technologies and their integration into manufacturing services.

The IVI focuses on improvements across a range of manufacturing operations including: production process engineering, production planning and control, quality system management, and maintenance planning.

The initiative emphasises its public good orientation and its SME technology diffusion function. Its work focuses on areas where firms "can naturally collaborate, while keeping each company's competitive advantage untouched". IVI solutions are made available to all members of the initiative, with advice available to help SMEs on how they might adapt them to their particular operations.

The IVI was established in June 2015 by Japan's Ministry of Enterprise, Trade and Industry (METI) and the Manufacturing Systems Division of the Japanese Society of Mechanical Engineers (JSME-MSD), with an initial membership of around 50 manufacturers (as of April 2017, membership exceeded 200 organisations). Stakeholders in the IVI include Japan's Robot Revolution Initiative Council and the Industrial Internet Consortium.

Programme Overview | Industrial Value Chain initiative (IVI)

Mission
Development and adoption of solutions combining manufacturing and ICT technologies in order to address common technical problems and improve manufacturing operations[1].

Focus
- Smart manufacturing, with emphasis on IoT solutions for manufacturing processes[1]

Approach
Working groups bring together experts from several companies to create 'smart manufacturing scenarios' based on real concerns / improvement opportunities identified in manufacturing operations. Scenarios might focus on processes within a firm or on the integration of processes across firms in the value chain.

Solutions (including tools, software and databases) combining manufacturing and ICT technologies are developed based on "loosely defined standards". This approach allows an agile development of solutions, and flexibility of adoption, adaptation and update.

Experiments are then conducted to verify whether IVI solutions address firms' needs. Solutions can be made available to all members of the initiative, with advice available to help SMEs on how they might adapt them to their particular operations.

Key Programme: Advanced Manufacturing IoT Kits for SMEs
One of the most recent efforts to increase adoption of IoT solutions by cash-constrained SMEs is the development of "¥100,000(~£700) IoT kits"[2].

These kits are developed by working groups, involving large and small companies, with the aim of achieving attractive prices by integrating low-cost components, such as the Raspberry Pi single-board computer.

To disseminate the benefits of the initiative among SMEs, the IVI works with municipalities and supporting organisations to hold seminars across Japanese regions.

Key activities
- In 2016, 25 'smart manufacturing scenarios' were developed, grouped across four areas[3]: production process engineering, production planning and control, quality system management and maintenance planning.

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	○	●
	Coordination failures	●	○	○
	Network failures	○	●	○
	Public good	○	○	●
WHAT Intended change in the system	New technology adoption	○	○	●
	Increased tech. development activity	○	●	○
	New market orientation	●	○	○
	New firm formation	●	○	○
	Industrial dialogue / best-practice sharing	○	○	●
	FDI attraction	●	○	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	○	○	●
	Knowledge use (firm capability)***	○	○	●

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

- The IVI has run 20 projects between September 2015 and March 2016, covering use cases in four areas[4]:
  - Reaction on changes in globally and locally connected factories
  - Emerging IoT technologies for production line management
  - Platform for the connected world in design and manufacturing
  - New era of human centric manufacturing powered by IoT
- Each of the above projects involves several companies, sometimes competitors, in a novel collaboration.

Stakeholders and Membership
- Stakeholders: Large manufacturers and SMEs; professional and industrial associations; research centres; universities; Robot Revolution Initiative Council; Industrial Internet Consortium
- Membership (as of April 2017): 77 large manufacturers; 51 SMEs; 62 supporting member organisations; 15 sponsor member organisations; 19 academic members

Sources

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[3] Industrial Value Chain Initiative (2016). An Outline of Smart Manufacturing Scenarios 2016.
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4.6

Industry 4.0 Transfer Projects at 'it's OWL' Cluster Initiative – Germany

The Technology-Network Intelligent Technical Systems OstWestfalenLippe (it's OWL) is a consortium-led initiative focused on key digitalisation topics at the heart of Industry 4.0. In particular, the consortium focuses on 'intelligent technical systems', which arise from the interplay of engineering and ICT. It's OWL research projects focus on the development of new technologies for self-optimisation, human-machine interaction, intelligent networking, energy efficiency and systems engineering.

It's OWL focuses not only on product innovation itself, but also on the development, deployment, maintenance, and life cycle management of new products and systems. In particular, during the second phase of its funding, the initiative places emphasis on transfer projects to make technologies and methods developed by the cluster available to SMEs.

It's OWL 'transfer concept' is based on a four-step model aimed at removing technology transfer barriers in SMEs. Through this concept, 60 firms were able to adopt new technologies from the Cluster through more than 70 transfer projects in two years (July 2014 to June 2016). These technology transfer projects received a total funding of over €3.5 million during this two-year period.

Programme Overview | Industry 4.0 Transfer Projects at IT'S OWL

Mission

It's OWL technology transfer aims to spread and implement technologies and methods developed by the it's OWL cluster among SMEs[1].

Focus Areas

It's OWL's work focuses on 'intelligent technical systems', which arise from the interplay of engineering and ICT. These types of systems adapt autonomously to the environment and the needs of users, cope with unexpected situations, and are both energy-efficient and reliable. Research projects focus on the development of new technologies for self-optimisation, human-machine interaction, intelligent networking, energy efficiency and systems engineering. Examples include self-optimising controls for machinery and equipment, intuitive human-machine interfaces and methods for energy management, and interdisciplinary product development.

Highlights

- Characteristics of transfer projects:
  - Collaboration between a research institute (transfer provider) and an industrial company (transfer recipient).
  - Last between five and ten months.
  - Both the transfer provider and the transfer recipient must be from the cluster region.
  - Around 120 transfer projects projected[2].
- The level of funding is approx. €30,000 per project, up to a maximum of €50,000. Full funding is provided for expenses incurred by the transfer provider (personnel and travel costs). The transfer recipients must cover their own expenses[2].

'Transfer Concept'

It's OWL 'transfer concept' aims to remove transfer barriers in SMEs. It is based on a four-step model:

- One: Companies are introduced to the IT's OWL technology platform and provided with basic information.
- Two: Firms' understanding of available content and solutions on particular technologies is enhanced, primarily through information events.
- Three: Expert discussions to identify concrete offers from the technology platform of interest. Workshops allow testing of technologies and solutions in a non-binding setting.
- Four: Targeted use and integration of the new technologies in companies by collaborations between transfer recipients and transfer providers.

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	○	●
	Coordination failures	○	●	○
	Network failures	○	●	○
	Public good	○	○	●
WHAT Intended change in the system	New technology adoption	○	○	●
	Increased tech. development activity	○	○	●
	New market orientation	●	○	○
	New firm formation	●	○	○
	Industrial dialogue / best-practice sharing	○	○	●
	FDI attraction	●	○	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	○	○	●
	Knowledge use (firm capability)***	○	○	●

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Budget

From July 2014 to June 2016, 58 companies introduced new technology from the Leading-Edge Cluster in a total of 73 transfer projects. These projects received a total funding amount of ~€3.5 million. Distribution according to technological fields: 20% intelligent networking; 20% systems engineering; 13% human-machine interaction; 11% self-optimisation and 9% energy efficiency[1].

Impact

An evaluation framework was designed with input from industry and academia. Assessments take place yearly, and follow a model focused on the 'effect chain model', 'Input – Output – Outcome – Impact'. As part of the evaluation, the partners concerned respond to an online survey[1].
Results from an initial evaluation survey[1]:

- 70% of all the companies surveyed rated the value of their project as 'very high'.
- Over two-thirds believed that participation in a project led to technological or methodological improvement in operations.
- Over 80% of companies believed that they found the right research partner for their project.

Sources

[1] it's OWL (2017). On the road to industry 4.0: technology transfer in the SME sector.
[2] it's OWL (ND). Requirements and criteria.

PROMOTING R&D AMONG SMES IN THE VALUE CHAINS

4.7

Federation of Industrial Research Associations (AiF) - Germany

The AiF is Germany's leading national organisation for the promotion of applied R&D in SMEs. It is an industry-driven organisation managing public programmes of the German federal government. The AiF and its research associations seek to provide comprehensive support in R&D matters to help SMEs to meet the challenges of technological change.

The 'AiF innovation network' consists of 100 industrial research associations, representing 50,000 businesses, mostly SMEs. Each research association represents a certain business sector, mostly SMEs, from specific branches of the economy or fields of technology. By taking an active part in the research association and its committees, SMEs influence the association's research agenda and priorities.

In 2014, the AiF disbursed around €500 million of its public funding, in particular, on behalf of the Federal Ministry for Economic Affairs and Energy (BMWi). Since its foundation in 1954, the AiF has disbursed more than €10 billion in funding for more than 200,000 research projects for SMEs.

Programme Overview | Federation of Industrial Research Associations (AiF)

Mission

The AiF aims at "initiating applied research and development for SMEs", as well as "qualifying the new generation of academics in innovative fields and organizing the distribution of scientific knowledge"[1].

Focus Areas

- The AiF support mechanisms and a funding focus on SMEs, SME associations or groups, and research organisations.
- Funding is open to all sectors and technologies, represented in the AiF's 100 industrial research associations, which in practice means a wide coverage across the economy.
- Preferred R&D focus: prenormative standardisation; product standardisation; technical tools; environmental solutions; generic industry demand; basic and process technologies[2].

Highlights

- The AiF's core activity is the so-called '**Industrial Collective Research**'. This is a funding mechanism enabling businesses to solve shared problems through applied research projects. The focus is on pre-competitive research to close the gap between basic research and industrial application.
- Research associations collect ideas for research projects and identify common research needs within an industrial branch or field of technology.
- An application for funding is then made to the AiF. The AiF, acting on behalf of the Ministry of Economic Affairs and Energy (BMWi), takes care of the administrative process, including the evaluation of proposals.
- The AiF manages the Cooperation Projects of the **Central Innovation Program for SME (ZIM)** on behalf of the BMWi (see section **4.8**).
- The AIF also coordinates the **Collective Research Networking (CORNET)**. This initiative facilitates international cooperation on the basis of existing national and regional funding schemes. Funded projects should have a maximum duration of 24 months. CORNET is characterised by high success rates (~66%) and short time to contract[3]. Results are also openly accessible for follow-up development in individual firms.

		Minor Emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	○	●
	Coordination failures	○	○	●
	Network failures	○	●	○
	Public good	○	○	●
WHAT Intended change in the system	New technology adoption	○	●	○
	Increased tech. development activity	○	○	●
	New market orientation	●	○	○
	New firm formation	●	○	○
	Industrial dialogue / best-practice sharing	○	●	○
	FDI attraction	●	○	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	○	○	●
	Knowledge use (firm capability)***	○	●	○

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Budget

- In 2016, the AiF disbursed €532 million of public funding, in particular on behalf of the BMWi[4]:
  - **Industrial Collective Research:** 1,754 projects funded with €139 million.
  - **ZIM:** 2,167 new R&D projects with a combined funding volume of €393 million were initiated.
  - The main technology fields funded were nanotechnology; production technologies; materials technologies; electrical engineering; health research and medical technology.
- Industrial Collective Research, Funding: approx. €200,000 per project in 2013[2].
- Since 1954, the AiF has disbursed more than €10 billion in funding for more than 200,000 research projects for SMEs.

Stakeholders

The AiF stakeholders include:

- 100 industrial research associations representing approx. 50,000 businesses, mostly SMEs
- 1,200 associated research institutes
- AiF's affiliates in Cologne and Berlin
- Universities
- Fraunhofer Institutes
- International partners in Austria; Belgium (Flanders, Wallonia); Canada (Québec); Switzerland; Czech Republic; Netherlands; Peru and Poland

Sources

[1] AiF (ND). About AiF.
[2] AiF (ND). Collective Research.
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[4] AiF (2017). Zahlen | Daten | Fakten 2016.
[5] CORNET (2017). Success stories.

4.8

Central Innovation Program for SMEs (ZIM) – Germany

The Central Innovation Program for SMEs (ZIM) is a nation-wide funding programme for SMEs, and for research organisations closely aligned with businesses. The focus of this programme is on SMEs that want to develop new, or significantly improve existing products, processes or technical services. Funding is open to German SMEs of all technologies and sectors (up to 499 employees and less than €50 million in annual turnover, or a balance sheet total of no more than €43 million).

ZIM has provided support for innovation efforts since 2008. More than €540 million are provided every year within this programme.

ZIM comprises different support measures:

- Single Projects (Funding of R&D projects undertaken by a single SME).
- Cooperation Projects (Funding of cooperative R&D projects between SMEs or SMEs and RTOs).
- Cooperation Networks (Funding of the management of innovative company networks, and R&D projects generated by them – with a minimum requirement of six German SME partners).
- Market launch of the results of the R&D projects.

Stakeholders involved in the operation of ZIM:

- The Federal Ministry for Economic Affairs and Energy.
- IraSME network.
- Bilateral agreements with: Alberta (Canada), Israel, Finland, South Korea and Vietnam.

Programme Overview | Central Innovation Program for SMEs (ZIM)

Mission

- Cooperation Projects & Networks: Central Innovation Program for SMEs (ZIM) aims to help SMEs to develop new or improve existing products, processes or technical services and to commercialise them[1].

Focus

- SMEs of all technologies and sectors[1].

Highlights

- The funding for individual and cooperation projects is awarded as a non-repayable grant in the form of co-financing up to the following rates based on the eligible costs.
- Maximum funding rates for individual projects and cooperation projects are between 25% and 55%.
- Research institutes can claim 100% of eligible project costs[1].
- For the market launch the maximum funding rate is 50%.
- Public and private non-profit research and technology organisations (RTOs) acting as a cooperation partner of a SME are also eligible for ZIM funding.

International Collaboration

- ZIM also constitutes the German funding scheme of the binational Germany-Singapore SME Funding Programme, which provides support for joint R&D projects between German and Singaporean SMEs. The Singaporean funding counterpart is the Capability Development Grant (CDG). The Germany-Singapore SME Funding Programme focuses on technological and application areas, in particular, applications from the Medical Technology, Clean Technology, and Advanced Manufacturing.l[2,3].

Budget

- During the period 2015-2017; 298 cooperation networks have been supported; 7,184 cooperation projects; and 1,717 individual projects. The number of individual projects represents 0.4% of the total number of German SMEs and 2.4% of the manufacturing SMEs.
- These projects have received a funding of about €1,430 million during the same period.
- The maximum project costs that are eligible for funding are €380,000 per company, and €190,000 per research institute[1].
- The maximum support available for network management is €380,000[1].
- For the market launch the eligible costs amount to €50,000[1].

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	●	○
	Coordination failures	○	○	●
	Network failures	○	●	○
	Public good	○	○	●
WHAT Intended change in the system	New technology adoption	○	○	●
	Increased tech. development activity	○	○	●
	New market orientation	○	●	○
	New firm formation	●	○	○
	Industrial dialogue / best-practice sharing	○	○	●
	FDI attraction	●	○	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	○	○	●
	Knowledge use (firm capability)***	○	○	●

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Impact

An evaluation conducted in 2016, found the following[8, 9]:

- From 2012 to 2015 the funded companies showed an average increase in their sales of nearly 12%, while the number of employees rose by 15%.
- More than half of the projects were carried out by small enterprises.
- Innovative networks projects
  - About 70 percent of companies were able to increase sales from 2012 to 2015.
  - An average 0.5 jobs were created and 2.4 jobs were retained.
  - Nearly 90% of the companies intensified cooperation with other companies.
- Lessons learned
  The level of technical achievement was larger in individual projects than in cooperative projects. This has been attributed to the higher complexity involved in cooperation projects.

Sources

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[2] SPRING Singapore - AiF Projekt GmbHGermany (2017). *Singapore SME Funding Programme*.
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[8] Depner *et al.* (2017). Wirksamkeit der geförderten FuE-Projekte des Zentralen Innovationsprogramm Mittelstand (ZIM). RKW Kompetenz-zentrum.
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4.9

New Mexico Small Business Assistance (NMSBA) Program – United States

The New Mexico Small Business Assistance (NMSBA) Program supports regional SME competitiveness through access to experts at the local Los Alamos National Laboratory and Sandia National Laboratories. Technical assistance is funded by the state and provided to businesses free-of-charge. The funding is provided through a national lab voucher program that, since 2000, has given access to over 1,000 small businesses to the Los Alamos and Sandia labs. The state government provides the funding for the vouchers through a partnership with the NMSBA.

Small businesses can participate in the NMSBA Program through three different types of projects:

- **Individual Projects.** Projects address challenges specific to the business that can be solved with the national laboratory expertise and resources.
- **Leveraged Projects.** This category of projects allows multiple small businesses that share technical challenges to request assistance collectively for a larger project.
- **Contract Projects.** Through this type of projects the NMSBA Program contracts entities that have the capability to provide small business assistance services, not available in the private sector, at a reasonable cost. Current contracts include New Mexico Manufacturing Extension Partnership, University of New Mexico's Anderson Schools of Management and Management of Technology Program, New Mexico Institute of Mining and Technology Department of Management, and New Mexico State University Arrowhead Centre.

Feedback from companies that participated in an economic impact client survey in 2014 revealed that: 57% developed a new product or technology; 52% improved overall operations; 53% became more competitive in the market place; 57% expanded or improved a product or service; and 52% improved the expertise or capabilities of employees.

Programme Overview | New Mexico Small Business Assistance (NMSBA)

Mission

The New Mexico Small Business Assistance (NMSBA) Program aims to provide technical assistance to small business facing technical challenges, at no cost to the business[1].

Focus

- For-profit small businesses.
- US Companies (owned and operated, located in New Mexico)[1].

Highlights

- NMSBA services are provided at no cost to the participating small businesses in the form of lab staff hours, valued at up to $20,000 per calendar year, for businesses located in rural counties, and $10,000 for businesses located in urban counties[2].

Budget

- The total amount of assistance is capped at $2.4 million annually for each laboratory[2].
- In 2015, through the Laboratory Partnership with Small Business Tax Credit Act, the state of New Mexico, along with Los Alamos National Laboratory and Sandia National Laboratories, invested nearly $5 million to help small businesses[2].

Impact

Outcome and impact metrics of the small businesses that received assistance from NMSBA (2000-2015):

- 2,495 businesses assisted (7% of all New Mexico SMEs)[3].
- $48.5 million of technical assistance has been provided in Los Alamos and Sandia national laboratories[4].
- 4,863 jobs have been created or retained as a result of the support received[3].
- 1.19 Return on Investment (ROI, based on salaries of jobs created and retained) [2].
- $38,768 mean salary[2].
- $236 million increase in revenue[2].
- $105 million decrease in operating costs[2].
- $98 million investment in New Mexico goods and services[2].
- $87 million new funding or financing received[2].

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	●	○
	Coordination failures	●	○	○
	Network failures	●	○	○
	Public good	○	○	●
WHAT Intended change in the system	New technology adoption	○	●	○
	Increased tech. development activity	○	○	●
	New market orientation	●	○	○
	New firm formation	●	○	○
	Industrial dialogue / best-practice sharing	●	○	○
	FDI attraction	●	○	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	○	●	○
	Knowledge use (firm capability)***	○	○	●

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Success stories

- *Biolime*. Lime-based structural coatings. Matching bioLime with materials suppliers in the Southwest saved the company approximately $25 million in avoided investment costs associated with site, equipment, and professional fees[2].
- *IR Dynamics*. Experiments related to spectrally controllable materials. When the technology showed promise, IR Dynamics was established. The thermally dynamic materials are in the form of nanoparticles. One of the principal applications of these nanoparticles is as a coating or film for windows in residential and commercial buildings. The company has raised $600,000 in private equity funding, secured $100,000 in grants, and received a $1.9 million grant from the Department of Energy[2].

Sources

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PROMOTING R&D AMONG SMES IN THE VALUE CHAINS

4.10 Small Business Innovation Research (SBIR, US)

4.11 Manufacturing USA institutes (US)

4.12 Precision Engineering Centre of Innovation, SIMTech (Singapore)

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4.10

Small Business Innovation Research (SBIR) – United States

The Small Business Innovation Research (SBIR) programme is an inter-agency policy that encourages small businesses to engage in 'Federal Research/Research and Development (R/R&D)' that has the potential for commercialisation. By reserving a specific percentage of federal R&D funds for small businesses, SBIR aims to enable them to compete on the same level as larger businesses.

SBIR focuses on: technological innovation; Federal R&D needs; participation in innovation and entrepreneurship by socially and economically disadvantaged persons; and increased private-sector commercialisation of innovations derived from Federal research and development funding.

The programme is overseen by the U.S. Small Business Administration (SBA), with participation from several Federal agencies:

- Department of Agriculture
- Department of Commerce - National Institute of Standards and Technology
- Department of Commerce - National Oceanic and Atmospheric
- Department of Defense
- Department of Education
- Department of Energy
- Department of Health and Human Services
- Department of Homeland Security
- Department of Transportation
- Environmental Protection Agency
- National Aeronautics and Space Administration
- The National Science Foundation

In 2014, $1.6 billion were provided in new awards, $488 million in Phase I awards and $1.1 billion in Phase II awards. Additionally, $41.2 million were granted in prior-year Phase I awards and $596 million in prior-year Phase II awards.

Programme Overview | Small Business Innovation Research (SBIR)

Mission

The Small Business Innovation Research (SBIR) programme aims to encourage domestic small businesses to engage in Federal Research/ Research and Development (R/R&D) that has the potential for commercialisation[1].

Eligibility

- SBIR is open to for-profit businesses located in the United States, who are at least 50% owned, and controlled by U.S. citizens or permanent residents, and with no more than 500 employees[2].

Funding approach

- Funding between $150,000 and $1,000,000 for up to 2 years.
- SBIR is structured in three phases[1]:
  - Phase I. The objective of this phase is to establish the technical merit, feasibility, and commercial potential of the proposed R/R&D project, and to determine the quality of performance of the small business awardee. SBIR Phase I awards does not normally exceed $150,000 for 6 months.
  - Phase II. Funding is based on results achieved in Phase I, and the scientific and technical merit and commercial potential of the project proposed in Phase II. SBIR Phase II awards do not normally exceed $1,000,000 for 2 years.
  - Phase III. The objective of this phase is for the small business to pursue commercialisation objectives resulting from the Phase I/II R/R&D activities. The SBIR program does not fund Phase III. Some Federal agencies may fund follow-on non-SBIR funded R&D, or production contracts for products, processes or services intended for use by the U.S. Government.

Budget

- In 2014, $1.6 billion were provided in 4,675 new awards, $488 million in Phase I awards and $1.1 billion in Phase II[3].
- Each Federal agency, with an extramural budget for R/R&D in excess of $100 million, must participate in the SBIR Program and reserve not less than 3.2% (FY 2017) of their extramural R/R&D budgets[4].
- In 2017 the obligated minimum amount to be awarded is ~$465 million [5].

Impact

- Impact evaluations have found positive economic impacts on: employment, GDP, labour income, sales of new products to Federal agencies, value added tax revenues. In addition, positive effects on the generation of knowledge-based outputs; funding projects with high scientific or social value but unlikely to generate significant market outcomes in the short term; formation of innovative small companies; and licensing revenues[6].

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	○	●
	Coordination failures	○	●	○
	Network failures	●	○	○
	Public good	○	●	○
WHAT Intended change in the system	New technology adoption	○	●	○
	Increased tech. development activity	○	○	●
	New market orientation	○	○	●
	New firm formation	○	●	○
	Industrial dialogue / best-practice sharing	●	○	○
	FDI attraction	●	○	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	●	○	○
	Knowledge use (firm capability)***	●	○	○

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Lessons learned

Some relevant recommendations that have emerged from impact and monitoring reports, include[1,6,7]:

- Improving support for the commercialisation of SBIR technologies, especially for smaller projects.
- Improving the participation by socially and economically disadvantaged small businesses, and by woman-owned small businesses (WOSBs).
- Improving data collection, monitoring, evaluation and assessment.
- Work done to define the necessary inter-database functionalities to ensure timely reporting of data and consistency of data across all agencies.
- Greater award size flexibility, especially for biomedical projects.

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4.11

Manufacturing USA Institutes – United States

The Manufacturing USA institutes are public-private partnerships that focus on critical advanced manufacturing technology areas. Originally labelled National Network of Manufacturing Innovation Institutes (NNMI), Manufacturing USA is an effort to bring together manufacturing innovation institutes, each one comprised of SMEs linked to larger firms, backed by multidisciplinary university applied science and engineering. The programme is operated by the interagency Advanced Manufacturing National Program Office (AMNPO).

Manufacturing USA aims to address the gap between R&D supported by government and product development in industry. It provides a support system for the stages of technology development and technology demonstration. Institutes operate at a regional level to take advantage of area-specific industrial clusters, but Manufacturing USA aims to translate the institutes' technology and process learning to manufacturers at a national level, and bring together the institutes around jointly learned lessons.

1,174 organisations participate in Manufacturing USA, including: SMEs to large multinational conglomerates; academia; not-for-profit organisations and Federal agencies.

The 14 institutes operating in July 2017 are the following:

- The National Additive Manufacturing Innovation Institute (America Makes)
- Digital Manufacturing and Design Innovation Institute (DMDII)
- Lightweight Innovations for Tomorrow (LIFT) Institute
- American Institute for Manufacturing Integrated Photonics (AIM Photonics)
- America's Flexible Hybrid Electronics Manufacturing Institute (NextFlex)
- Institute for Advanced Composites Manufacturing Innovation (IACMI)
- The Next Generation Power Electronics Manufacturing Innovation Institute (PowerAmerica)
- Clean energy: Clean Energy Smart Manufacturing Innovation Institute (CESMII)
- Reducing Embodied-energy and Decreasing Emissions (REMADE) Institute
- Advanced Robotics for Manufacturing (ARM) Institute
- Advanced Functional Fabrics of America Alliance (AFFAA)
- Advanced Regenerative Manufacturing Institute (ARMI)
- Rapid Advancement in Process Intensification Deployment Institute (RAPID)
- National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL)

Programme Overview | Manufacturing USA Institutes

Mission

The Manufacturing USA institutes aim to bridge the gap between R&D supported by government and the product development role of industry[1].

The programme goals are defined as follows[2]:

- Increase the competitiveness of U.S. manufacturing.
- Facilitate the transition of innovative technologies into scalable, cost- effective, and high-performing domestic manufacturing capabilities.
- Accelerate the development of an advanced manufacturing workforce.
- Support business models that help Institutes become stable and sustainable.

Budget

- Each of the 14 advanced manufacturing institutes has received Federal funding for an amount between $55 million and $110 million.
- This funding has been matched with non-federal resources (local governments and other key partners) for an amount between $55 million and $502 million [3-9].

Impact

Some positive results of the work of the Institutes:

- Decrease the cost of R&D experimentation by providing access to expensive equipment, pooling project costs, creating technology roadmaps, and promoting knowledge exchange.
- Collaboration through common agreements on IP and partnerships that would be prohibitively expensive and time-consuming to be negotiated on a case-by-case basis.
- Help industry mitigate the talent gap by coordinating workforce activities conducted by members and external stakeholders.
- Strengthen regional economic clusters, creating and reinforcing connections between firms that are geographically concentrated [2].

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	●	○
	Coordination failures	○	○	●
	Network failures	○	●	○
	Public good	○	○	●
WHAT Intended change in the system	New technology adoption	○	●	○
	Increased tech. development activity	○	○	●
	New market orientation	○	●	○
	New firm formation	○	●	○
	Industrial dialogue / best-practice sharing	○	○	●
	FDI attraction	○	●	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	○	○	●
	Knowledge use (firm capability)***	○	●	○

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Lessons learned

Some relevant recommendations that have emerged from external assessments[2,11]:

- Develop and execute an overarching strategy that accounts for the complementarities, overlaps and competition between institutes.
- Increase public awareness through strategic communications.
- Institutes' work on technology development should emphasise transition and deployment activities to increase commercialisation. This will also avoid the risk of overlap with other R&D organisations such as national labs.
- Less restrictive contracting and membership agreements should be supported to allow Institutes to respond at the speed of industry.
- Use four criteria to select the technology areas that respond to industry demands and not only agency missions: industry or market pull; cross-cutting; national or economic security; leveraging US strengths.
- Consider mechanisms for continuing federal funding beyond the initial 5 years.
- Adapt the research governance model to the complex role of the institutes, which is broader than R&D.
- Embrace a more full supply chain approach, engaging the stakeholders in technology demonstration, testing and training.

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4.12

Precision Engineering Centre of Innovation, SIMTech (Singapore)

The Precision Engineering Centre of Innovation (PE COI), at the Singapore Institute of Manufacturing Technologies (SIMTech), focuses on the advancement of precision engineering competencies that represent the 'backbone' of manufacturing. PE COI offers a broad spectrum of technologies, manpower training, consultancy, and comprehensive facilities to meet the manufacturing needs of local PE companies. PE COI core capabilities include: machining, forming, joining, surface engineering, mechatronics, measurements and diagnostics.

Some of the Collaborative Industry Projects conducted by PE COI are:

- 3D Additive Manufacturing (AM) Capabilities of Metal and Polymer Parts. This CIP aims to enhance companies' competency in 3D AM, allowing them to explore new business opportunities and upgrade their manufacturing capabilities.
- Advanced Machining Dynamics Analysis Technology for Productivity and Quality Improvement. This CIP aims to enhance the machining productivity and quality of local manufacturing industry in precision machining (milling and turning) of steel and non-ferrous metals through technology transfer and customisation.
- Low Cost 3D Printing for Dental Crowns and Bridges. This CIP aims to implement a low cost bottom up stereolithography process technology to manufacture dental copings, bridges frameworks and zirconia crowns.

Programme Overview | Precision Engineering Centre of Innovation, SIMTech

Mission

The Precision Engineering Centre of Innovation (PE COI) aims to help PE SMEs leverage state-of-the-art technology for innovations to sustain and advance their businesses [1].

Focus

- SMEs in the manufacturing sector, including manpower, facilities, and IT resources (firms with at least 30% local equity, and sales of not more than $100 million, or employment not more than 200 workers).
- Eight core industries: Oil & Gas, Aerospace, MedTech, Complex Equipment, Operations innovation, Surface Finishing, and Engineering Design & Simulation[2].

Highlights

In 2016 the PE COI launched the Collaborative Commerce Marketplace (ACCM). This is a free online portal that highlights the capabilities of Singaporean SMEs as prospective suppliers for MNCs. The platform also allows SMEs to gain insights to the needs of MNCs[3,4].

Budget

- From 2007 to 2011, the PE COI has completed more than 135 industry projects, closed more than 100 consultancy cases, and organised more than 100 events, which reached out to some 3,000 participants[2].

Success story

Enabling SMEs to enter Aviation Industry Through Collaborative Industry Project.

- 4 SMEs upgraded knowledge in design, simulation and manufacturing of aviation-standard polymeric components.
- Transferred precision moulding technologies to fabricate high performance aircraft interior components.
- Guided and trained qualified suppliers of aviation components to SIA[4].

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	○	●
	Coordination failures	○	●	○
	Network failures	○	○	●
	Public good	○	●	○
WHAT Intended change in the system	New technology adoption	○	○	●
	Increased tech. development activity	○	○	●
	New market orientation	○	○	●
	New firm formation	○	●	○
	Industrial dialogue / best-practice sharing	○	○	●
	FDI attraction	○	○	●
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	●	○
	Knowledge diffusion (linkages & institutions)**	○	○	●
	Knowledge use (firm capability)***	○	○	●

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

Example Services

- Showcase and Promotion
  - Material, Process and Product Innovation.
  - Business Model and Operations Innovation.
  - Overseas mission trips, roundtable and networking sessions.
- Knowledge Transfer
  - Specialist skills training.
  - Qualifications (WSQ) Specialist and Graduate Diploma courses.
- Technology Transfer
  - Develop capabilities and intellectual property on process and automation technologies.
  - Transfer of technologies.
- Industry Development
  - Advisory support and consultancy.
  - Sharing of resources.
  - Collaborative development of industry initiatives.

Sources

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4.13

Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT) – Japan

The Impulsing Paradigm Change through Disruptive Technologies (ImPACT) program supports disruptive innovation expected to transform the industry and society through the promotion of high-risk and high-impact R&D. ImPACT aims to help arrest the decline in the competitiveness of Japanese industry and Japan's corporate leaders' loss of confidence in their economy.

The ImPACT programme has two main goals:

- Create disruptive innovation
- Present to the business world an action model for innovation

Research costs are allocated to R&D institutions by the Japan Science and Technology Agency (JST). The funding covers direct costs (equipment and materials, travel personnel); indirect costs (10% or less of the direct costs); support costs (program manager costs); and fund management costs. The transfer (sale, merger, etc.) of intellectual property rights acquired through an R&D program requires approval by the JST.

ImPACT has adopted a project manager (PM) approach, which gives PMs high authority and comprehensive budgets. The PMs determine their own targets and select their own research team – allowing flexibility to achieve the target of a 'deep transformation' in industry and society.

¥55 billion (~£392 million) were approved in the fiscal year 2013 to be spent until fiscal year 2018.

Programme Overview | Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT)

Mission

Japan's Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT) aims to build a 'new science and technology system in which universities and corporations can boldly tackle challenging research issues and open new areas of growth'[1].

Focus Areas

Key ImPACT themes:

- Japan-style value creation for the new century. Release from constraints on resources and innovation in "monozukuri (manufacturing)" capabilities.
- Living in harmony with the world. Realisation of an ecologically sound society and innovative energy conservation that changes lifestyles.
- Smart community that links people with society. Realisation of a society of highly advanced functionality that surpasses the information networked society.
- Realise healthy and comfortable lives for everybody. Provide the world's most comfortable living environment in a society with a declining birth rate and aging population.
- Realise a resilience that is keenly felt by every individual Japanese. Control the impact and minimise the damage from hazards and natural disasters that are beyond human knowledge [2].

Project Manager Approach

ImPACT has incorporated a project manager (PM) approach, where the PM is not a researcher but a "producer" who sets targets, chooses a "cast" of the best researchers and implements high-risk, high-impact R&D[1].

Allocation of R&D funds and IP

Research costs are allocated to R&D institutions by the Japan Science and Technology Agency (JST). The funding covers direct costs (equipment and materials, travel personnel), indirect costs (10% or less of the direct costs), support costs (program manager costs) and fund management costs. The transfer (sale, merger, etc.) of intellectual property rights acquired through an R&D program requires approval by the JST.

In the event that funding is granted to an institution, outside Japan to participate as an R&D institution, a share of 50% or more of the intellectual property rights, acquired through the implementation of ImPACT research, is to be assigned to the JST.

		Minor emphasis	Some emphasis	Primary emphasis
WHY Rationale for intervention	Information failures	○	●	○
	Coordination failures	○	○	●
	Network failures	●	○	○
	Public good	○	●	○
WHAT Intended change in the system	New technology adoption	○	○	●
	Increased tech. development activity	○	○	●
	New market orientation	○	○	●
	New firm formation	○	●	○
	Industrial dialogue / best-practice sharing	○	○	●
	FDI attraction	●	○	○
HOW Interventions funded by programme	Knowledge generation (basic and applied R&D)*	○	○	●
	Knowledge diffusion (linkages & institutions)**	●	○	○
	Knowledge use (firm capability)***	●	○	○

* **'Knowledge generation'** includes basic and applied research and development activities related to new technologies, tools and techniques.
** **'Knowledge diffusion'** include activities to facilitate the diffusion of knowledge and know-how (including standard development, creation of industrial networks, and industrial and market intelligence gathering).
*** **'Knowledge use'** includes activities to support firm access and application of new technological knowledge (including training, access to expertise & facilities, and new product development support).

R&D programmes

IMPACT has established 16 R&D programmes, among them:

- Realizing Ultra-Thin and Flexible Tough Polymers.
- Achieving Ultimate Green IT Devices with Long Usage Time without Charging.
- Actualize Energetic Life by Creating Brain Information Industries.
- Artificial Cell Reactor Technology for an Enriched and Secure Society and New Bioengineering.
- Bionic Humanoids Propelling New Industrial Revolution[1].

Budget

- ¥55 billion (~ £392 million) were approved in the fiscal year 2013 to be spent until fiscal year 2018[1].
- Research costs are allocated to R&D institutions and that allocation is carried out by the JST according to commissioned research contracts[3].

Sources

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5

Discussion and policy implications

The case studies, discussed in **Section 4,** illustrate a variety of international approaches and practices for strengthening industrial value chain capabilities. Differences can be observed across basic programme characteristics, including: primary missions; types of institutions involved; budget size and funding models; scale and coverage; and diversity of 'system focus' (sector, manufacturing system, technology, etc.). More fundamentally, the case studies provide a number of lessons and policy implications, which are discussed in this section:

- **The need to build the evidence base, on opportunities and challenges across UK sectors, for effective policy design and delivery**
- **The need to ensure that the national institutional infrastructure enables a decentralised policy delivery – including the ability to engage with firms across regions**
- **The need to systematically account for the particular challenges faced by SMEs for engaging in research and innovation activities**
- **The need for efforts beyond R&D and knowledge generation to ensure policy impact**
- **The need for performance metrics beyond productivity and R&D**

Building the evidence base, on opportunities and challenges across UK sectors, for effective policy design and delivery

Effective design of support programmes and initiatives requires the building of a robust evidence base, on particular value capture opportunities for UK value chains, on the challenges constraining firms from pursuing them, and also on how policy interventions might make a difference. Because this information cannot be readily elicited from traditional economic statistics, **systematically collecting evidence across the four opportunity areas, discussed in this report, could be a first step for supporting effective policy making in the UK.**

A robust evidence base, across sectors in the economy, could help policy makers identify cross-cutting themes and establish priorities for action – both in terms of new programme design, as well as in institutional capability building. While some efforts have been made to produce relevant evidence in some UK sectors (a number of studies have been produced to identify domestic supply opportunities in, for example, the automotive industry), information across sectors is not readily available to policy makers.

The type of opportunities, targeted by the programmes and initiatives, has direct implications on, for example, the knowledge that programme managers require about them. For example, generic SME support programmes, and R&D promotion initiatives, might seek to have an impact across the board and, as such, these programmes may be open to any firm, regardless of the sector it operates in. No specialised knowledge might be required about firms' existing capabilities. This is the case, for example, for the **US Manufacturing Extension Partnership (MEP)**, and **Germany's Central Innovation Program for SMEs (ZIM)**, which are open to firms from all sectors and technology areas. This is the case, for example, in the **Supplier Development Initiative (SDI)** at the **Singapore Institute of Manufacturing Technologies (SIMTech**). It gathers information about the specific supply chain needs of large firms recently established in the country, as well as the capabilities of the local SMEs in the pool of their client firms, to assess their suitability as potential suppliers.

New communication channels and improved levels of access to firms, as well as new institutionalised evidence gathering functions, may also be required. Ensuring that the needs of different types of firms in the value chain are systematically captured, across the variety of government-supported initiatives, and that the information is shared among relevant departments and agencies, could be useful steps in this direction.

Ensuring that the national institutional infrastructure enables decentralised policy delivery – including the ability to engage with firms across regions

The case studies, presented in the report, clearly show that the analysis of programmes and initiatives cannot be disconnected from considerations about the institutions charged with implementing them. In particular, the number of firms that a programme is able to reach (i.e. its coverage) is determined by a number of institutional factors. These include the extent to which the implementing institutions are spread across regions in the country, the network of other institutions they partner with, and the number of firms that their field advisors are able to engage with.

Policy makers might be compelled to create new programmes, to address identified challenges and opportunities, but it might first be necessary to consider whether the institutional infrastructure in the country is 'fit for purpose'. The international experience suggests that simply creating new programmes and initiatives might not be sufficient, as some programmes might only work if certain types of institutions with the required coverage exist in the country. A key enabling factor for the **US Manufacturing Extension Partnership (MEP)**, for instance, is its network of nearly 600 offices and Centres serving firms in all of the US states. This decentralised presence allows the programme to reach over 11% of all SMEs in the country. Similarly, Germany's **Federation of Industrial Research Associations (AiF)'s** network, of 100 industrial research associations across the country, is able to reach 50,000 businesses, mostly SMEs. Such level of coverage cannot be replicated without regional institutions having the capacity to engage with firms throughout the country.

In order to ensure effective policy delivery, efforts to nurture institutions might be as, if not more, important than the establishment of new programmes and initiatives. Effective support strategies require a long-term approach to build the institutions that are needed, with the size, coverage and financial flexibility required, in order to deliver the intended support. Institutions also have a role to play in capturing evidence about the changing needs and capabilities of firms and sectors across regions. Decentralised facilities might be required, as well as partnerships between research and technology organisations, industry associations, professional bodies, and universities.

Systematically accounting for the particular challenges faced by SMEs for engaging in research and innovation activities

Enhancing national industrial competitiveness might only be possible if all types of companies, leaders and followers, are able to participate in the transformations made possible through innovation. Yet evidence suggests that smaller firms find it more difficult to engage in innovation. The smaller the company is, the harder it finds it, to innovate or capitalise on its innovations.

Policy efforts, aimed at supporting SMEs in the value chain, need to take into account that smaller firms might not have the time, capacity or funds to keep up-to-date about available sources of support, let alone to engage in them. The international review reveals that a variety of modalities and technical mechanisms are employed to promote SME engagement. This includes considerations regarding both the type of support made available to firms, and the level of financial contribution required from the private sector.

Germany's **It's OWL Transfer Projects**, for example, adopts a phased process to help remove barriers preventing SMEs from adopting new technologies. Efforts are first made to build SME's understanding of the technologies, through information events, and at a later stage, demonstration workshops. As SMEs become more knowledgeable, relevant vendors are identified, collaborations are established, and technical support is provided to help SMEs adopt new technologies into their processes.

In terms of finance, some programmes can fund up to 50% of the eligible costs of a collaborative project between SMEs and large companies, while other initiatives could either fund 100% of eligible project costs, or even provide services (i.e. access to laboratories, technical advice) completely free of charge to SMEs. The **New Mexico Small Business Assistance (NMSBA) Program**, for example, provides SMEs with technical assistance at the local national laboratories free-of-charge. The funding is provided through a voucher program funded by the state government. There are, of course, a number of relevant considerations regarding what may or may not be allowed in the context of State aid rules that are currently applicable in the UK.

A prominent example of a large-scale national institution, specifically aimed at initiating SME engagement in R&D, is Germany's **Federation of Industrial Research Associations (AiF)**. Recognising the difficulty that SMEs face in engaging in R&D by themselves, AiF's "Industrial Collective Research" mechanism brings together groups of SMEs, to identify their common needs, with the support of industrial research associations. In 2014 alone, the AiF disbursed around €500 million of public funding.

Other initiatives, analysed, reveal the importance of industrial networks, involving SMEs and large firms, for eliciting information about opportunity areas. Such networks can help to identify the opportunity areas to be exploited, as well as areas where policy action might be required. Some of the programmes analysed are specifically focused on building a stronger cooperation between small firms and large companies by funding collaborative projects.

Efforts beyond R&D and knowledge generation to ensure policy impact

Ensuring that policy efforts achieve their intended impact requires a broad conception of innovation. Capability challenges, faced by firms along the value chain, cut across policy areas – from skills and infrastructure to R&D and finance – and thus no single programme might be able to address all of them. In order to overcome barriers to innovation, firms might require a combination of 'soft support' (such as the provision of information and support to create industrial networks around common interests) and 'hard support' (hands-on support through activities such as training, contract research, and expert advice).

Yet the debate around innovation, in both academia and policy making, tends to focus on instruments to promote knowledge generation (primarily based on the provision of R&D funding). Additional (soft and hard) types of support might be required to support knowledge diffusion and application, which are critical to ensuring efficient translation into industry. Beyond funding R&D, ensuring the intended impact of innovation programmes might also require efforts in areas including: pilot line and test-bed demonstration, development of skilled technicians and engineers, regional firm consortia formation, SME capacity building and participation in new supply chains, and the attraction of FDI.

A broader conception of innovation functions is evident in some of the recent initiatives reviewed in this study. For example, the **Manufacturing USA institutes** in the USA, place particular emphasis on the opportunities of using R&D competencies, to support SME growth and supply chain development, and carry out specialised technician training. Some of the institutes also host facilities that serve as test beds, to demonstrate the possibilities of new technologies to interested companies.

Performance metrics beyond R&D and productivity

Policy makers should assess whether performance indicators properly account for the systemic nature of the modern industries, and the dynamics of innovation within them. Relying solely on R&D-related metrics (such as the numbers of publications and patents) might not provide meaningful guidance regarding the impact of innovation and competitiveness policies. Even in the case of R&D-focused programmes, the number of new firms involved in R&D might be more important than the number of papers and patents produced. This is the case, for example, when it comes to the promotion of R&D among value chain SMEs. Germany's **It's OWL** programme, for example, places emphasis on technological and methodological improvements achieved by firms, as a consequence of engagement on R&D. Meanwhile, **AiF** places emphasis on the total number of research projects supported and in which SMEs are involved.

The cases reviewed in this study reveal that, when compared to the UK, other countries place less emphasis on productivity measures. A variety of performance indicators are used, with more careful attention given to the particular capability challenges that institutions and programmes seek to address. Productivity measures might not be the most relevant, for example, when assessing the impact of programmes aimed at addressing domestic supply opportunities. In such cases, targets on overall industry levels of local sourcing might be more directly relevant. Moreover, measurements of productivity might differ at firm, sector and national levels. At firm level, for example, measures of factory utilisation, production throughput, and material use efficiency are commonly used. At the sectoral and national level, measures of value added per capita tend to be the most common.

Finally, because emerging innovation challenges are increasingly becoming multidisciplinary, requiring a combination of capabilities and specialised infrastructure that no single actor possesses; measures to enhance institutional linkages and strengthen interdisciplinarity are becoming increasing relevant. Recent international efforts place emphasis on bringing together the right mix of research and innovation capabilities, facilities and partnerships, required to drive innovations. This is the case of, for example, Japan's **Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT),** which allows programme managers to seek out the required capabilities across the country.

6

Conclusions

The objective of this report has been to inform policy efforts aimed at promoting industrial innovation and competitiveness, by providing insights into international policy practices and approaches. The report discusses key concepts and definitions relevant to understanding the role of domestic suppliers in modern industries, reviews programmes and initiatives in selected countries, and suggests policy implications for the UK. Case studies have been selected to help inform UK policy development by illustrating the variety of international policy missions and approaches in areas of particular relevance to the UK.

Section 2 provided a theoretical foundation to the study, by introducing key concepts and working definitions drawn from the academic and policy literatures. The intention has been to provide insights into the "system" that policy interventions are expected to influence, with emphasis on the structure and configuration of the sectors, and the "ecology of suppliers" within them. **Section 3** identified four opportunity areas for strengthening value chain capabilities of particular relevance to the UK. **Section 4** presented a selection of case studies that provide insights into international approaches and practices for supporting industrial innovation and competitiveness. Case studies provided indications of what has been considered to be effective in other countries. Policy implications emerging from this international review are presented in **Section 5**. To some extent, this discussion provides useful guidance for practical policy design and implementation.

Given the limited scope of this project, only a selection of case studies, from a number of advanced countries, has been carried out in detail. Further work could expand the number of programmes and countries covered in the review. It is important to note that evaluations of the programmes, and initiatives reviewed here, are not always publicly available. It is, therefore, not possible to make definite statements regarding the effectiveness of particular policy efforts of how they might compare with alternative approaches. However, the case studies, presented here, provide a useful international context by describing some of the most prominent efforts established in competitor countries to promote industrial innovation and competitiveness. Future work should also focus on building the evidence base on value capture opportunities across UK sectors (not least across the opportunity areas described in Section 3). Particular attention should be given to the appropriate role for government, and whether particular gaps in the UK national institutional infrastructure might be constraining effective policy design and delivery.

Appendix 1
Extended Concepts and Definitions

Manufacturing

A series of example definitions of manufacturing are provided below, from basic descriptions to the more advanced and comprehensive ones, as follows:

- "To make or produce goods in large quantities, using machinery" (Oxford Dictionary, 2017)[57]
- "The process of converting materials into usable products through human skill and knowledge" (National Academy of Engineering, 2012)[58]
- "…a business system encompassing all activities required to deliver products that meet customer needs... extends from R&D, design, engineering, to production, finance, sales, marketing, and after-sales service... extends beyond any single enterprise, across increasingly global supply chains and business networks" (Canadian Manufacturers & Exporters, 2005)[59]
- There is increasing recognition of the complex interactions and interdependencies between industries, technologies and services associated with the manufacture of many modern products, which themselves are often highly complex systems in their own right (PCAST, 2011; Tassey, 2010; Brecher, 2012)[60]

Supply chain

Narrow and broad definitions of supply chain are provided to arrive at the concept of a "supply network", where two or more supply chains are linked together:

- "A supply chain is a set of firms that pass materials forward" (La Londe and Masters, 1994)[61]
- "A supply chain is defined as a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer" (Mentzer *et al* 2001)[62]
- "The supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer" (Christopher, 2011)[63]
- The supply chain links many companies together, starting with unprocessed raw materials and ending with the final customer using the finished goods (CSCMP, 2017)[64]

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[57] Oxford English Dictionary (2017). Manufacture.
[58] NAE (National Academy of Engineering) (2012). "Making things: 21st century manufacturing & design", report of a Symposium of the National Academy of Engineering, National Academies Press.
[59] CME (Canadian Manufacturers & Exporters) (2005). The future of manufacturing in Canada: Perspectives and Recommendations on International Business Development. Canadian Manufacturers and Exporters.
[60] PCAST (2011). Report to the President on Ensuring American Leadership in Advanced Manufacturing. President's Council of Advisors on Science and Technology. Executive Office of the President; Tassey (2010). Rationales and mechanisms for revitalizing US manufacturing R&D strategies, J. Technol. Transf; Brecher, C. (Ed.) (2012). Integrative Production Technologies for High Wage Countries. Springer.
[61] La Londe and Masters (1994). "Emerging Logistics Strategies: Blueprints for the Next Century", International Journal of Physical Distribution & Logistics Management. (check rest of reference inserted is correct)
[62] Mentzer et al. (2001). "Defining Supply Chain Management", Journal of Business Logistics, Vol 22, N 2.
[63] Christopher (2011). Logistics & Supply Chain Management. Pearson.
[64] CSCMP (2017). "Supply Chain Management Terms and Glossary". Council of Supply Chain Management Professionals.

- "A supply chain is the network of activities that delivers a finished product or service to the customer. These include sourcing raw materials and parts, manufacturing and assembling the products, warehousing, order entry and tracking, distribution through the channels, and delivery to the customer. An organization's supply chain is facilitated by an information system that allows relevant information such as sales data, sales forecasts, and promotions to be shared among members of the supply chain" (Reid and Sanders, 2013)[65]
- "Supply chain is a linkage or strand of operations that provides goods and services through to end-customers; within a supply network several supply chains will cross through an individual operation". On the other hand, "a supply network perspective means setting an operation in the context of all the other operations with which it interacts, some of which are its suppliers and its customers….Every operation is part of a larger and interconnected network of other operations. This supply network will include suppliers and customers. It will also include suppliers' suppliers and customers' customers, and so on" (Slack *et al* 2013)[66].

Concept related to supply chain

- **OEM - Original Equipment Manufacturer**: the company designing and assembling components for a product sold to consumers (i.e. Ford, Airbus, Apple)
- **Tier 1, Tier 2, Tier 3…:** a tier company is defined according to its commercial relation with the OEM: E.g., a Tier 1 firm has a direct relationship with OEM; a Tier 2 sells parts/components to a Tier 1, but not to the OEM – and so on…

Value chain

- Michael Porter (1985)[67] introduced the concept of Value chain. The value chain analysis describes the activities the organisation performs and links them to the organisation's competitive position. Following Porter (1985, p 33), "*competitive advantage cannot be understood by looking at a firm as a whole. It stems from the many discrete activities a firm performs in designing, producing, marketing, delivering, and supporting its product. Each of these activities can contribute to a firm's relative cost position and create a basis for differentiation … The value chain disaggregates a firm into its strategically relevant activities in order to understand the behaviour of costs and the existing and potential sources of differentiation. A firm gains competitive advantage by performing these strategically important activities more cheaply or better than its competitors*". Porter (1985) therefore analyses each of the activities where an organisation is involved, distinguishing between primary and secondary activities, as follows:
    - Primary activities:
        - Inbound Logistics (i.e. relationships with suppliers)
        - Operations (i.e. transformation of inputs into outputs)
        - Outbound Logistics (i.e. collection, storing and distribution)
        - Marketing and Sales (i.e. inform and induce buyers to purchase a product)

[65] Reid R. D. and Sanders N. R. (2013). Operations Management: an Integrated Approach. 5th edition. John Wiley & Sons, Inc.
[66] Slack et al (2013). Operations Managements. 7th edition. Pearson.
[67] Porter M. (1985). Competitive Advantage. Creating and Sustaining Superior Performance. The Free Press.

    - Service (i.e. aftersales services)
- Secondary activities
    - Procurement (i.e. the acquisition of inputs)
    - Human Resource management
    - Technological Development
    - Infrastructure

- The concept of a value chain has been further developed to remark upon the fact that several types of value chains may compose an industrial system (i.e. agricultural and forestry product value chain, automotive value chains, electronics and semiconductor value chains and so on) (UNIDO, 2009)[68]. Value chains may also be distinguished according to the degree of linkages among the activities and operations involved (i.e. the single value chain; the extended value chain; and the multiple value chains, where activities of one value chain are crossed with activities and operations of another or more value chains) (Kaplinsky and Morris, 2000)[69]. Furthermore, Gereffi (1995)[70] proposes a classification of a value chain based on the "dominating actors and governance" of the value chain itself (i.e. buyer-driven vs supplier-driven value chain; very loosely coordinated, market-based trading structures versus intensely coordinated, vertically integrated, value chains).

Global value chain

- After Porter's analysis, the analysis of a value chain has shifted from the single firm to the interconnected set of firms that together create the value added of the product.
- UNIDO (2009) definition: a value chain can be seen as "a set of businesses, activities and relationships engaged in creating a final product (or service). It builds on the idea that a product is rarely consumed in its original form but becomes transformed, combined with other products, transported, packaged, marketed etc. until it reaches its final consumer".
- Over time the analysis of a value chain has been focused on the integration of domestic firms into production networks at international level. The concept of Global Value Chains was introduced.
- UNIDO (2009) definition: "Global value chains can be understood as networks of functionally interrelated producers and buyers that are engaged on a global scale in processes of value creation as products pass across borders and between different actors in the chain"
- OECD (2012)[71] definition: global value chain "reflect a strong trend towards the dispersion of value chain activities across the world. Many companies have broken up their value chains and distributed production stages across many countries; at the same time, they have outsourced parts of their value chains to external partners"

[68] UNIDO (2009). "Value Chain Diagnostics for Industrial Development. Building blocks for a holistic and rapid analytical tool". UNIDO Working Paper. United Nations Industrial Development Organization.
[69] Kaplinsky and Morris (2000). A Handbook for Value Chain Research. Prepared for the IDRC.
[70] Gereffi *et al.* (2005). The Governance of Global Value Chain. Review of International Political Economy 12:1.
[71] OECD (2012). *Interconnected Economies. Benefiting from Global Value Chains.* OECD.

Appendix 2
Full list of international case studies

This appendix presents a long list of initiatives and programmes established in other countries to support the development of supply chain capabilities. Over 60 national initiatives and programmes (most of them government-led) have been reviewed. In discussions with BEIS, 13 of them have been selected for more detailed analysis (Section 4).

Insights from the international review can help inform policy making in the UK by illustrating the variety of analysis, institutions and levels of funding that have been deployed to support value chain capability development. The review also provides, to some extent, indications of what has been considered to be effective in other countries.

It is worth noting that, for the purposes of this study, the selection does not include the following type of programmes and initiatives: purely financial measures; programmes for export promotion/overseas business development; generic FDI promotion policies; generic start-up promotion/support; programmes/university accelerators; and measures purely based on taxation.

Programmes and initiatives are organised by country, including: Canada, China, the European Union, Germany, Japan, Singapore, Sweden, Taiwan and the United States.

Long list of case studies	
Country	**Name of the programme**
Canada	Industrial Research Assistance Program (IRAP)
China	National Manufacturing Innovation Centres
	China Academy of Sciences (CAS) Innovation 2020
	Shanghai Technology Transfer & Exchange (STTE)
European Union	EU Pilot lines for Key Enabling Technologies (KETs)
	INNOSUP initiative
	The Enterprise Europe Network
	European Institute of Innovation and Technology (EIT)
Germany	German Federation of Industrial Research Associations (AiF)
	Cooperation Projects and Networks, Central Innovation Program for SMEs (ZIM Cooperation Projects and Networks)
	IraSME
	IT's OWL (Intelligent Technical Systems OstWestfalenLippe)
	Cluster of Excellence Integrative Production Technology for High-Wage Countries
	WIPANO (Knowledge and technology transfer via patents and standards programme)
Japan	Industrial Value Chain initiative (IVI)
	Global Niche Top Companies Selection 100
	Cross-Ministerial Strategic Innovation Promotion Program (SIP)
	Impulsing Paradigm Change through Disruptive Technologies (ImPACT) program
	Automotive Human Resource Development Project (AHRDP) (2006-2011)
	Programme to promote bridge research and development to second-tier companies and SMEs
	Support for the promotion of new business activities/collaboration of agriculture, commerce and manufacturing
	Utsukushima (Beautiful Fukushima) Next-Generation Medical Industry Agglomeration Project
	Regional Industry Tie-up program (RIT)
Singapore	Precision Engineering Centre of Innovation, SIMTech
	Capability Development Grant (CDG)
	Germany-Singapore SME Funding Programme
	Collaborative Industry Projects (CIP)
	Partnerships for Capability Transformation (PACT) initiative
	National Trade Platform
	Startup SG Tech grant
	Innovation & Capability Voucher (ICV)
	Technology Adoption Programme (TAP)
	Local Enterprise and Association Development (LEAD) programme
	SIMTech's Knowledge Transfer Office (KTO)
	SIMTech technology licensing
	SIMTech Membership Programme
	Precision Engineering Centre of Innovation (PE COI)
	Manufacturing Productivity Technology Centre (MPTC)
	Sustainable Manufacturing Centre (SMC)
	Technology for Enterprise Capability Upgrading (T-UP)
	Operation & Technology Roadmapping (OTR)
	Tech Depot
	A*STAR collaborative commerce marketplace (ACCM)
Sweden	Vinnova Sweden
Taiwan	Industrial Technology Research Institute (ITRI)

Long list of case studies	
Country	**Name of the programme**
United States	Manufacturing USA
	Hollings Manufacturing Extension Partnership (MEP)
	Supplier Improvement and Supply Chain Optimization, Hollings Manufacturing Extension Partnership (MEP)
	Supplier Scouting and Business-to-Business Networks Hollings Manufacturing Extension Partnership (MEP)
	Supply Chain Technology Acceleration, Hollings Manufacturing Extension Partnership (MEP)
	Department of Defense Office of Economic Adjustment (OEA)
	Department of Energy (DoE) – National labs
	New Mexico Small Business Assistance (NMSBA) programme
	The SupplierPay Initiative
	Advanced Manufacturing Technology (AMTech) Program
	Small Business Innovation Research (SBIR) program
	Small Business Technology Transfer (STTR)
	Clean Energy Manufacturing Analysis Center (CEMAC)
	National Robotics Initiative (NRI)
	National Nanomanufacturing Network (NNN)
	Coalition for Automotive Lightweighting Materials (CALM)
	Enterprise Innovation Institute (EI^2, Georgia Tech)
	Georgia Tech Manufacturing Institute (GTMI)

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