



Sheffield  
University  
Management  
School.

# DIFFUSING INDUSTRY 4.0

## Understanding Barriers to Digitalisation in Manufacturing SMEs

### **AUTHORS:**

CRISTIAN GHERHES,  
TIM VORLEY  
AND  
CHAY BROOKS

**MARCH 2020**



## ABOUT US

The Centre for Regional Economic and Enterprise Development (CREED) at Sheffield University Management School has a long-standing reputation for high quality high impact research in the fields of innovation, entrepreneurship enterprise economic development. CREED is actively involved in number of national and international research projects developing new insights that seek to advance research, policy and practice.

### Contact us

✉ [creed@sheffield.ac.uk](mailto:creed@sheffield.ac.uk)

🐦 [@CREED\\_Research](https://twitter.com/CREED_Research)

## ACKNOWLEDGEMENTS

We are grateful for the support from the Faculty of Social Sciences at the University of Sheffield, who provided seed corn funding for the study via the Economic and Social Research Council (ESRC) Impact Acceleration Account. We would also like to express our thanks to all of the SMEs and stakeholders who generously granted us access and provided their time to contribute to the scoping study, and to Dale Riahi who assisted with stakeholder engagement and data collection.



# FOREWORD

Manufacturing is a key part of the UK economy, and continues to be of strategic importance as a sector. However, to ensure that UK manufacturing businesses realise their potential and continue to be globally competitive amidst the 4th industrial revolution, there is a need to embrace new technological developments.

We are seeing the advent of Industry 4.0 which has the capacity to significantly transform UK manufacturing. Where businesses, and SMEs especially, are supported in the adoption of new industrial digital technologies there is considerable potential to improve productivity, increase exports and unlock new levels of growth. In particular, the automation of manufacturing, using real time data to drive efficiencies in the production process, represents a major opportunity for the sector. The UK is well-positioned to realise these opportunities brought by industrial digitalisation, with much of the technology already widely available and increasingly affordable.

However, there are still significant barriers facing SMEs in particular in adopting Industry 4.0 technologies, many of which are non-technological. The specific nature of SMEs means that major decisions, such as digitalisation and technology adoption, are reliant on owner-managers. At the same time, competing short-term financial demands tend to postpone larger investments that would otherwise help ensure long-term competitiveness and sustainability. Coupled with time constraints, uncertainty, confusion and a lack of understanding of the new technological landscape, such issues can significantly hinder digitalisation in SMEs and the more rapid diffusion of industrial digital technologies.

If the UK is to remain globally competitive in an increasingly digitalised economy, we need our manufacturing SMEs to be forward thinking and open to the opportunities that digitalisation and Industry 4.0 present. Given the importance of SMEs to the UK economy, providing relevant and timely support to SMEs to support digitalisation, accelerate technology adoption, and increase the Industry 4.0 readiness of the sector is critical for the future of UK manufacturing.



**Professor Rab Scott**

*Head of Digital  
AMRC*

# CONTENTS

About Us	2
Acknowledgements	2
<b>FOREWORD</b>	3
<b>EXECUTIVE SUMMARY</b>	5
<b>PART I - SMES AND THE NEW INDUSTRIAL AGE</b>	7
A New Industrial Paradigm: Digitalisation and Industry 4.0	8
UK Manufacturing MADE SMARTER	8
Manufacturing SMEs in Focus	9
<b>PART II - DOING DIGITAL</b>	11
Seeing Return on Investment	13
Minding the physical-to-digital gap	15
Size matters: the disconnect between supply and demand	16
<b>PART III - REFLECTIONS &amp; RECOMMENDATIONS</b>	19
Reflections	20
Recommendations	21
<b>AFTERWORD</b>	23
References	25

# EXECUTIVE SUMMARY

New data-intensive technological developments are driving the shift towards a new industrial paradigm, the so-called Fourth Industrial Revolution or Industry 4.0. These are changing the nature of manufacturing, bringing significant opportunities for enhanced economic and productivity growth. The Made Smarter Review published in 2017, backed by the UK's new Industrial Strategy, recognised the strategic importance of the manufacturing sector to UK's economy and set out a framework to support the adoption of industrial digital technologies across the sector.

In the UK, the manufacturing sector accounts for 14% of the economy, 10 % of employment, 50% of UK exports and more than 70% of Research & Development activity. While the UK has seen a decline in manufacturing, digitalisation represents a key opportunity to revive the sector and unlock new opportunities for economic and productivity growth. However, the Made Smarter Review identified key challenges to the diffusion of industrial digital technologies, among which is the low level of adoption of such technologies, especially among the SMEs within the sector.

Given the importance of SME for UK's economy, accelerating the diffusion of Industry 4.0 technologies within manufacturing SMEs is critical to unlocking the potential for productivity gains. This scoping study focuses on understanding barriers to digitalisation in manufacturing SMEs, reporting findings based on 20 interviews conducted with owner-managers of manufacturing SMEs from a range of sub-sectors as well as technology suppliers and research & technology organisations. The report highlights 4 key barriers that are holding SMEs back from becoming Industry 4.0 ready, hindering the more rapid diffusion of industrial digital technologies:

1. *The lack of absorptive capacity constrains SMEs' ability to understand and adopt Industry 4.0 technologies.*
2. *The challenge of demonstrating the cost-effectiveness of digitalisation makes it difficult to predict return on investment, deterring investment in new technologies.*
3. *A physical-to-digital gap needs to be closed through technologies that enable the capture and use of data from operations before more advanced technologies can be adopted.*
4. *A disconnect between technology suppliers and manufacturing SMEs has led to 'fancier' technologies being developed as opposed to practical solutions that address the needs of SMEs.*

If the UK is to become a global leader in industrial digitalisation, it is critical to address both supply and demand side challenges. While manufacturing SMEs need to become more receptive to Industry 4.0 technologies, there is significant scope for Government to support and target digitalisation in SME. The report offers a number of reflections and recommendations to guide policy development. Against a backdrop of low productivity levels and increased international competition, accelerating the diffusion of industrial digital technologies in SMEs can be the decisive factor.



Nils  
Hetz

Deutsche Akademie für  
Fernsehen und Digitale



## **Part I**

---

# **SMEs and the New Industrial Age**

## A NEW INDUSTRIAL PARADIGM: DIGITALISATION AND INDUSTRY 4.0

“Ever since the beginning of industrialization, technological leaps have led to paradigm shifts which today are ex-post named “industrial revolutions”: in the field of mechanization (the so-called 1st industrial revolution), of the intensive use of electrical energy (the so-called 2nd industrial revolution), and of the widespread digitalization (the so-called 3rd industrial revolution). On the basis of an advanced digitalization within factories, the combination of Internet technologies and future-oriented technologies in the field of “smart” objects (machines and products) seems to result in a new fundamental paradigm shift in industrial production.”<sup>1</sup>

The nature of manufacturing is changing. Advancements in Information & Communication Technology (ICT) have spurred new technological developments such as Cloud Computing, Big Data, Robotics, Artificial Intelligence (AI), Additive Manufacturing (3D Printing), Augmented and Virtual Reality, and the Internet of Things (IoT). Together, these are driving what has come to be known as the Fourth Industrial Revolution, or Industry 4.0, a new paradigm of digital-based manufacturing promising significant disruption but also benefits and gains in productivity to industry and beyond.<sup>2</sup>

Industry 4.0 is fuelled by both application-pull and technology-push factors.<sup>3</sup> Application-pull is driven by social, economic and political changes which increasingly demand short development periods, individualisation on demand, flexibility, decentralisation, and resource efficiency that can be affected by digital solutions. On the other hand, technology-push is driven by further increasing mechanisation and automation, networking, and miniaturisation where digitalisation is a key mechanism underpinning technological change.

Industry 4.0 is underpinned by a physical-to-digital-to-physical (PDP) loop whereby the physical and digital worlds communicate and affect each other through a cyclical flow of information and actions.<sup>4</sup> In this loop data is collected from the physical world, about supply chains, processes, and operations (P), which is then fed into the next phase of the loop where it is processed in the digital world (D) and subjected to advanced analytics. Finally, algorithms and automation facilitate and enable transformations in the physical world (P). The 4 main technologies enabling this loop are Data Technology, Analytics Technology, Platforms Technology and Operations Technology.<sup>5</sup> Together, these enable data acquisition, conversion, analysis and visualisation to support decision-making and actions. While parts of the cycle, such as physical-to-digital processes of capturing information or digital-to-digital analytics, may already be in place in many organisations, “It is the leap from digital back to physical ... the ability to act upon data and information that has been analyzed—that constitutes the essence and value of Industry 4.0”.<sup>6</sup>

The combination of advanced factory digitalisation, Internet technologies and ‘smart’ objects is expected to fundamentally reshape industrial production.<sup>7</sup> As such, “Industry 4.0 is ushering in a digital reality that may alter the rules of production, operations, workforce—even society”.<sup>8</sup> In this context, it is critical that manufacturing firms ‘future proof’ their operations and become Industry 4.0 ready or otherwise risk being left behind or crowded out by competitors.

## UK MANUFACTURING MADE SMARTER

The UK lags behind its peers in terms of overall productivity (i.e. output per worker), with very modest productivity growth recorded since 2008, and lower levels of adoption of digital and automation technology are seen as a key part of this ‘productivity puzzle’. As other nations are already exploiting and benefitting from advances in ICT, digitalisation has come to be regarded as a potential key driver of productivity growth in the UK.<sup>9</sup>

Despite the decline in manufacturing as a proportion of the economy, the manufacturing sector continues to be of strategic importance to the UK, accounting for 14% of the economy and 10% of employment, with more than 2.6 million people employed directly.<sup>10</sup> As the Industrial Strategy White Paper published by the UK Government in November 2017 highlights, manufacturing accounts for 50% of UK exports and more than 70% of Research & Development (R&D). Critically, advances in digital technologies present a key opportunity to revive the sector by creating efficiencies and driving productivity and growth across the sector.

The industry-led Made Smarter Review published in 2017 by a group of experts led by Prof Juergen Maier, CEO of Siemens UK, sets out a growth vision for the UK manufacturing sector driven by the potential of industrial digital technologies. The report highlights that the UK is well-placed to harness the transformative potential of digital technologies such as Artificial Intelligence (AI), Robotics, and the Internet of Things (IOT) and thus lead on industrial digitalisation and become a significant global player.

The report identifies three key challenges to achieving this vision. These are: a lack of effective leadership, poor levels of adoption, particularly among SMEs, and under-leveraged innovation assets. This report focuses on scoping the adoption challenges facing manufacturing SMEs with a view to understanding barriers to digitalisation. A key priority identified by the Made Smarter Review is rapid adoption which targets the diffusion and faster uptake of industrial digital technologies by manufacturing firms and in particular SMEs. However, if digitalisation in the manufacturing sector is to be a 'tide that lifts all boats', it is critical that the adoption challenges facing manufacturing SMEs are understood and addressed.

## MANUFACTURING SMES IN FOCUS

SMEs account for more than 99% of all UK businesses. However, a key challenge facing the UK as a whole is the 'long-tail' of low-productivity SMEs<sup>11</sup>, with some 75% of UK businesses existing within this tail.<sup>12</sup> Given the high proportion of SMEs and the promises of digitalisation, the SME sector provides significant opportunities for growth. As such, the UK economy stands to benefit significantly by lifting the 'long tail' and making the SMEs more productive through digitalisation.

Nevertheless, the Made Smarter Review shows that UK manufacturing SMEs have poor adoption levels of digital technologies. Besides more general barriers of skills shortage, an ineffective and confused business support landscape, and insufficient tax incentives, the report highlights risks around cybersecurity, a lack of common standards allowing different technologies to connect, and access to funding to support investment as key barriers to adoption perceived by SMEs. The report also refers to risk and investment aversion, a lack of time, capacity and funding to partner with universities or research and technology organisations and high costs for technology companies in engaging with large numbers of SMEs. However, given the importance of SMEs to the sector and the wider economy, there is a need to better understand what holds manufacturing SMEs back from catching up with Industry 4.0 and what Government can do to support them.

This report is the output of a scoping study which focused on barriers to digitalisation in manufacturing SMEs and was undertaken to understand the fundamental challenges to adopting Industry 4.0 technologies. There is general recognition across the sector of the need to engage with new and upcoming Industry 4.0 technologies to ensure long-term survival. However, we find that a lack of absorptive capacity, the challenges of demonstrating the return on investment (ROI) and cost-effectiveness of digitalisation, a physical-to-digital gap largely overlooked by existing technology products and services, and a disconnect between Industry 4.0 technology suppliers and manufacturing SMEs, deter many manufacturing SMEs from adopting industrial digital technologies, keeping adoption levels low. The report concludes with reflections and recommendations for policy on how to stimulate digitalisation to increase and speed up the diffusion of Industry 4.0 to manufacturing SMEs.

The findings in this report are based on interviews with manufacturing SMEs from various sub-sectors as well as with a number of other key stakeholders, specifically technology suppliers and research and technology organisations. These focused on establishing how firms conceptualise Industry 4.0, the challenges to collecting and leveraging operational data and investing in, adopting and integrating digital technologies, and covered both firm-based issues as well as the external market and policy environments. In addition, the researchers attended an investment pitching competition involving Industry 4.0 technology start-ups and a manufacturing group meeting that brought together manufacturing SMEs and Industry 4.0 technology suppliers. This provided additional insight into the current technological landscape, the type of Industry 4.0 technologies being developed, and SMEs' attitude towards digitalisation. The remainder of the report presents the key findings from the interviews and concludes with reflections and recommendations on how to support the wider diffusion of Industry 4.0.



## Part II

---

# Doing Digital



Four key themes emerged as central to the experience of firms in this study. First, the lack of absorptive capacity constrains SMEs' ability to understand and adopt Industry 4.0 technologies. Second, the fact that it can be difficult to predict benefits and ROI related to technology adoption can deter investment in this area. Third, while the narrative of Industry 4.0 centres on 'fancy' enabling technologies, there is a physical-to-digital gap that needs to be closed before closing the Industry 4.0 loop. Fourth, a disconnect between Industry 4.0 technology suppliers and manufacturing SMEs suppresses adoption levels.

*'There's no way around Industry 4.0 ... You either accept it or slowly shrivel up and die.'*

## A CONSTRAINT OF SMALLNESS

Overall, the manufacturing SMEs acknowledged the 'adapt-or-die' nature of Industry 4.0, recognising that adopting associated advanced technologies is the only way to survive and operate in a digitalised future. There was clear acknowledgment that large organisations were and will continue to leverage new technologies to increase their competitive advantage and productivity by further streamlining their internal operations and processes, increasing the interoperability of their technological systems and developing new products and services. However, none of the SMEs interviewed got anywhere near adopting the sort of advanced technologies associated with Industry 4.0 and many have yet to digitalise their operations.

Part of the problem can be attributed to the lack of what is known in the management literature as absorptive capacity. This is defined as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends".<sup>13</sup> In this sense, while the SMEs interviewed recognised the value of industrial digital technologies, they lack the time and capabilities required to understand their application and facilitate their adoption. Indeed, most SMEs simply cannot afford the time to investigate such issues as their priorities lie heavily with the day-to-day running of the business. This is especially the case in smaller SMEs where the owner-manager is the dominant actor.<sup>14</sup>

*'We're not anywhere near Industry 4.0 at the moment ... We're more like Industry 2.5.'*

Given the high number of roles they need to perform, SME owner-managers often stretch themselves to ensure the survival or short-term success of their organisations. This often sees them caught between running and managing the business, leaving little spare time to be able to consider projects with longer-term benefits that take them away from the more immediate requirements of everyday production activities. As such, researching Industry 4.0 and future-proofing current operations is a cost that many simply cannot afford. Even for those who have considered the adoption of digital technologies and realised their value - as was the case for an SME that tested different Customer Relationship Management (CRM) systems - day-to-day business concerns kept getting in the way of experimenting with and fully implementing the technology.

*'If you're an SME, you don't have the time to actually say "look, go off, find out what's happening in Industry 4.0".'*

As a consequence, many of the SME owner-managers interviewed had a limited understanding of Industry 4.0 and its potential application within their business. Critically, the lack of understanding of how to acquire and apply new technologies within their areas, and how they would fit into their business operations is a key barrier to adoption. While most were aware of the likes of Robotics, Analytics, Virtual Reality (VR) and Augmented Reality (AR) and their heralded benefits, the specific application of such technologies within their businesses remains an unanswered question.

‘When you’re a small business owner and you’re doing 50–60 hours a week, there’s no spare time to look for anything else in the market. You’re solely focused on keeping your business afloat.’

Even in the case of additive manufacturing technology, where applicability can be more evident than in the case of other advanced digital technologies, some SMEs struggled to understand its relevance and application potential within their specific sub-sectors. This issue was coupled with a constant focus of Industry 4.0 promoters on highlighting the more ‘sexy bits’ of Industry 4.0, as described by some interviewees. As these are the least understood, it further discourages SME manufacturers from devoting time and resources to investigating their application and adoption, causing many to deem such advanced technologies irrelevant.

In addition, those that have adopted some form of industrial technologies and implemented them as part of their operations were faced with the issue of lack of relevant specialist skills or knowledge. For example, two SMEs that have adopted industrial technologies identified the technological capabilities available in-house but were unable to capitalise on them and take full advantage of the new technologies because of a shortage of employees with specialised skills and programming capabilities. Another SME which was able to train its employees in how to use digital technologies across operations lacked the capabilities required to adopt more advanced technologies, while another deemed itself simply too small to consider automation and more advanced associated technologies.

‘It’s not always immediately apparent what is the benefit you’re going to get through [the new technologies].’

Finally, an “always done it this way and it works” mentality is a cultural trait shared by many SMEs and often serves as a “comfort blanket” for the lack of understanding of new technologies and their applicability. One of the technology suppliers described it as the most dangerous phrase in business because it maintains a perception that Industry 4.0 is still something too remote to be concerned about and prepare for. This relates to broader cultural issues around norms and resistance to change in SMEs.<sup>15</sup> Coupled with little pressure and incentives to change, this mentality further serves to maintain the status quo and to justify a perceived lack of need to invest in Industry 4.0.

## SEEING RETURN ON INVESTMENT

The Made Smarter Review identified risk aversion, lack of access to funding, and preconceptions that industrial digital technologies are too expensive and risky as some of the key barriers to digitalisation in manufacturing SMEs. Indeed, the cost of Industry 4.0 technology was mentioned by all the SMEs interviewed as a major deterrent. Given that the successful implementation of many Industry 4.0 technologies often requires large initial investments, the perception of many SME manufacturers is that such advancements are simply out of their reach. Investment in technology is seen as a commercial decision competing for resources with other higher priority needs such as sales generation. In addition, raising capital to invest in upgrading to Industry 4.0 is also more difficult for SMEs. Even those who were experiencing growth found it very difficult to access funding in order to invest in robotics and automation, and available cash was insufficient due to the demands of business growth.

‘The biggest barrier against new tech is the “we’ve always done it this way” mentality.’

However, the interviews showed that in addition to the cost of the technology, the difficulty and oftentimes inability, to demonstrate the benefits and cost-effectiveness to be able to justify the investment ultimately deters SMEs from pursuing digitalisation. In this sense, the majority of those interviewed highlighted the importance of achieving a desired ROI. While large enterprises have the infrastructure and resources, and are

able to harness existing capabilities, to maximise investments in advanced technologies, SMEs are afraid of having to wait for too long to get their investments back. As such, it is not simply the cost but more so the excessive amount of time or uncertainty around how long it will take for the investment in technology to break even that matters.

Importantly, the nature of the investment also makes it more difficult for SMEs to calculate and predict the ROI. Unlike machinery, where companies have clear information about inputs and outputs and are therefore better able to estimate ROI, it is more difficult to quantify the overall adoption costs involved and the cost savings that would result from the adoption of a particular digital technology, and thus to predict outcomes. The difficulty to demonstrate an accurate and desired ROI contributes negatively to the already existing perceptions that Industry 4.0 is expensive. Contributing to this is the fact that, as highlighted by the technology suppliers, investments in Industry 4.0 tend to be perceived as IT projects which, in the past, very often overpromised and underdelivered or overran on costs. This then creates the perception that new technologies may end up being even more expensive than they already cost, adding to existing uncertainties.

On top of that, there is a fear that new technologies will become obsolete at a higher rate than machines. While the machines currently employed by some SMEs are old and deemed 'legacy equipment', they are in fact seen as not only reliable and easy to fix and maintain but also resalable. Consequently, the perceived risk involved in such an investment is much smaller as, if the need to upgrade machinery arises, there is still residual value in the older machines. This highlights that, more than a risk aversion and a preference to "sweat their assets", as the Made Smarter Review identifies, the difficulty in demonstrating cost-effectiveness also deters SMEs.

However, technology adoption is not solely down to the prospect of generating a desired ROI. Spending a large percentage of their budget on new technologies that do little more than making it easier for employees to complete their tasks but without providing any clear and obvious benefits is what ultimately makes many SMEs postpone investing in digitalisation. This issue relates to the promotion of the 'sexy bits' of Industry 4.0 which, while desirable, are not perceived as solving any pressing operational needs, and therefore as absolutely necessary.

In other words, as emphasised by an interviewee, the key issue is that the price point often does not match the benefit of the technology to trigger an investment decision. In this sense, the report supports the argument made in the Made Smarter Review that the value of digitalisation, and especially that of data, needs to be demonstrated. Given the additional resource challenges facing SMEs, this is all the more important in their case.

There were cases where SMEs invested in digitalisation when all decision-makers were in agreement that it would benefit their organisation, despite an inability to quantify the cost savings. For example, one interviewee adopted a streamlined digital software package to digitalise their handwritten and unconnected spreadsheets. Here, the company's management concluded that the SME was failing in simple places and thus could not continue to operate the processes manually. It had no choice but to digitalise the manual processes. Critically, it must be noted that the company identified a pressing need for a piece of technology, rather than a merely a want.

**'They're not trying to be Industry 4.0 ready for Industry 4.0 ready's sake. They're doing it if it can save them time and money and resources.'**

**'Whatever the investment, it would have to be a year payback otherwise I wouldn't do it.'**

**'It's really hard to actually work out the cost of adopting Industry 4.0 technologies like robotics accurately and the return on investment.'**

**'There's a lot of companies who still have paper documentation, and that's because it works for them, and they won't digitalise unless there's a clear and obvious reason to move away from it.'**

**'I don't want to just give the technology to my employees because it makes their life a little bit easier but I'm going to see my money back in 30 years.'**

## MINDING THE PHYSICAL-TO-DIGITAL GAP

'You can't do AI or unless you've got the data ... There's a focus on the AI and the "sexy terms", but you've got to have the basics there first. It all starts with getting the data.'

'We'll probably renew our machinery more often, but it's the Industry 4.0 bit of the technology—the internet, the connectedness, the getting the data and digitalising the processes that's missing.'

'A key challenge is the systems that the company currently operates which do not facilitate the effective creation of document trails. We need to put a digital infrastructure into the business to support the value stream on the documentation side.'

'Industry 4.0 is described as the cyber-physical revolution. That basically just means the Internet of Things. It doesn't really mean AI, VR, AR, all that. It just means we capture and use data ... I do think the sector missed a step.'

The concept of Industry 4.0 is primarily and heavily focused on the so called 'sexy bits' of digitalisation—very advanced technologies such as AI, Machine Learning, Big Data Analytics and AR. However, the fact that such technologies are currently perceived to be either irrelevant, too costly, or desirable but not absolutely necessary, makes it all the more difficult to demonstrate their value to SMEs.

Importantly, the interviews revealed that part of the problem relates to the focus of and areas targeted by the new technologies, which tends to revolve more around closing the loop by bridging the digital and physical. The issue here is that the Industry 4.0 narrative is missing a critical step for SMEs. Specifically, as emphasised by a technology supplier, the foundation of Industry 4.0 is data, yet many manufacturing SMEs have not implemented the basic technology and/or processes required to collect data from their operations. For example, many of the SMEs interviewed believed that Industry 4.0 and digital technologies were not completely compatible with the factories that they operated. They were, in many cases, old factories lacking the required physical infrastructure to support digitalisation, such as basic network cables. Some asserted that Wi-Fi signals could not be transmitted across their factories.

While the majority of those interviewed were using some form of technology, the data they were collecting was coming primarily from sales management tools such as Customer Relationship Management (CRM) systems and accounting software used in isolation, as opposed to technologies that enable the collection of data from manufacturing operations. Given that Industry 4.0 relates specifically to the manufacturing-dedicated digitalisation of business,<sup>16</sup> there was very little evidence of this in SMEs' case. For many, pen and paper and handwritten notes continue to be the norm, and this is especially the case for those using older, legacy equipment. Others, who did digitalise some parts of their operations, were dealing with legacy software that was outdated and did little in the way of collecting and providing useful data. Moreover, those who considered the adoption of Industry 4.0 technologies soon realised the need to first have a digital infrastructure in place to support more advanced technologies.

As such, transitioning to Industry 4.0 and adopting advanced technologies is too large of a leap for many SMEs. Many identified the need to first adopt more basic digital technologies geared at collecting data from existing machines, such as tracking production processes by collecting data during production. For example, one SME introduced monitoring software which produces more accurate readings than was previously possible from the control panels that are part of the machines. However, the likes of Big Data analytics, simulation and AI were not even on the radar of those interviewed. These are perceived as something not only remote but also currently impossible to adopt due to what became apparent as a physical-to-digital gap.

This gap relates in particular to the lack of adoption of what has been referred to as Data Technologies.<sup>17</sup> These enable the successful acquisition of useful data by identifying the appropriate equipment and mechanism but also, importantly, data communication which creates the cyclical flow of information between the physical and digital worlds. A key challenge for SMEs here is the continued extraction of value from 'legacy equipment', as much

of the Industry 4.0 and digital technologies were not developed and designed with such equipment in mind.

Without the basic digital infrastructure to enable more advanced technologies to be 'plugged in', Industry 4.0 risks being perceived as, but also remain, irrelevant for the majority of SME manufacturers. While Industry 4.0 manufacturing is the end goal, a physical-digital coupling is first required in many manufacturing SMEs before a wider cyber-physical revolution can take place. For example, one of the SMEs which has implemented an internal cloud-based network system that enables staff to operate off-site recognised this as a simple but fundamental step that now enables it to consider the adoption of automation and robotics. In another case, an SME was able to eliminate a shift by implementing a digital system that enabled remote monitoring of machinery as well as performing diagnostics on the technology that it licenses and exports to clients. Importantly, not only can the implementation of digital solutions yield productivity gains, but this can enable, or even kickstart, the next phase of the PDP loop.

This section therefore supports the argument made by the Made Smarter Review that the digitalisation journey needs to start with practical steps that capitalise on existing capabilities, such as digitalising legacy systems. This is essential given the need for adoption to cause minimal disruption to a company's operations, as SMEs cannot absorb the costs of severe disruption to business operations. However, the next and final section highlights why digitalisation remains a challenge in the current context.

## SIZE MATTERS: THE DISCONNECT BETWEEN SUPPLY AND DEMAND

A major issue uncovered by the interviews is the lack of wider industry traction and appetite for Industry 4.0 beyond a very small number of top manufacturers referred to as 'the 1%'. These are seen as the government-backed driving force behind industrial digitalisation. Indeed, the current narrative of Industry 4.0 is largely pushed by Government in face of international pressures and increased competition, with large companies often acting as the 'poster child'. One interviewee referred to these companies as 'the establishment'. They have sizeable budgets and the resources and capacity to invest in, adopt, and implement advanced technologies. Due to their size, they benefit from economies of scale and can therefore achieve quicker wins that, in the words of an interviewee, gives them "bigger boosts", thus making the investment worthwhile. This also allows them to absorb the cost of the investment if it fails or does not pay off, which is not the case for most SMEs.

Indeed, the majority of SME owner-managers interviewed strongly associated the concept and promotion of Industry 4.0 and 'smart factories' with large enterprises. On one hand, the disconnect in the narrative has created a perception among manufacturing SMEs that Industry 4.0 is "not for me" or something that they should be concerned about in the near future. On the other hand, this has come to fundamentally shape the focus of Industry 4.0 technology suppliers. Specifically, the technologies and products developed by the majority of technology suppliers, including Industry 4.0 start-ups,

'The vast majority of Industry 4.0 is premised on data intensive AI and Machine Learning [but] 99% of manufacturers are SMEs using largely manual processes and legacy machines.'

'Industry 4.0 is being pushed by the government and large enterprises. You've got 1% of manufacturers driving it, you've got the government driving it through things like Made Smarter, but the majority of manufacturers aren't asking for it.'

'We looked at a very generic Internet of Things platform in which you can build applications, but there's no application built specifically for our needs.'

**‘People want to create things which are “sexy”, rather than things that work. That is probably the biggest problem with Industry 4.0.’**

revolve around issues facing larger enterprises or those who are already early adopters of Industry 4.0. These include generic cloud-based platforms, which are not tailored to the needs of SMEs and their specific sub-sectors, and cybersecurity—a concern for those who are already further on their Industry 4.0 adoption journey.

Beyond the lack of fit of existing digital technology products and services, their price acts as an additional deterrent. For example, many of the subscription services currently offered by some Industry 4.0 start-ups exceed £1,000 per month and can go up to £2,000 per month, a cost that many SMEs cannot afford in an entire financial year. Therefore, very few of the existing technologies and software solutions are suited to the needs and financial capabilities of the SME market. Part of the problem goes back to the focus on fancier technologies as opposed to practical solutions that address current gaps and needs and is driven by a focus of both large software providers and Industry 4.0 start-ups on serving market leaders. This highlights a level of disengagement between technology suppliers and manufacturing SMEs which serves to erode SMEs’ confidence in digital technologies.

**‘The challenge for an SME in the manufacturing sector will be what to use. What technology’s available? What is right for me? How can I use it? How can I implement it? What’s sustainable?’\**

As a consequence, the landscape is characterised by significant confusion and uncertainty with regard to the fit and viability of digital products and services currently available on the market. Moreover, the SMEs interviewed highlighted that technology suppliers tend to be viewed in a less positive light due to a lack of trust. Many mentioned that the main goal of suppliers is to sell their products and services rather than understand the real needs of SME manufacturers and assist with implementation. This lack of trust further deters SMEs from considering the adoption of digital technologies.

**‘We need more of these demonstrators for SMEs, particularly focused on SMEs rather than big companies.’**

Finally, all the stakeholders emphasised the need for more proofs of concept for SME-oriented technologies. The majority of the SMEs interviewed identified themselves as followers rather than early adopters of innovation, mentioning the need for more real-life examples of how Industry 4.0 can work in a manufacturing environment. Critically, such demonstrations of the benefits and use of Industry 4.0 need to take place in an organisation that SMEs can relate to, hence another SME manufacturer. The argument is that this would allow them to better understand how they could replicate the positive results within their own operations and demonstrate to and reassure SMEs that the investment is worthwhile.

**‘Manufacturers don’t want to be a first adopter. They don’t want to be early adopters. They want proof it’s worked elsewhere first.’**

These findings show that manufacturing SMEs face a unique constellation of disincentives and barriers to adopting Industry 4.0 technologies. While our interviews demonstrate that there is a broad recognition among SMEs in this sector that digital solutions might yield improved productivity performance, there is a reluctance to invest because these technologies are perceived as unrealistic for their business case. This perception is driven in part by the lack of comprehension of the technologies and/or internal capacity to adopt them, by the related challenge of predicting ROI, by the limited adoption of basic technologies that enable the latter stages in the Industry 4.0 loop, and by a disconnect between the technologies provided and SME needs. Fortunately, identifying these challenges enables us to develop interventions to affect the adoption of Industry 4.0 technologies. The next section offers some reflections on these findings and proposes some recommendations for the next generation of industrial policy.



## Part III

---

# Reflections & Recommendations



## REFLECTIONS

SMEs account for more than 99% of all UK businesses, providing significant opportunities for economic and productivity growth. This can be achieved by unlocking the potential of digitalisation to drive productivity gains in SMEs. The Made Smarter Review emphasised the importance of manufacturing to UK's economy and of manufacturing SMEs to the sector, as well as the opportunity to increase productivity through the adoption of industrial digital technologies which are driving Industry 4.0. However, it also highlighted the low adoption of these technologies in manufacturing SMEs. As this scoping study has set out, digitalisation through the adoption and diffusion of Industry 4.0 technologies has been slow in manufacturing SMEs. While the SMEs consulted acknowledged the importance of becoming Industry 4.0 ready for long-term survival and growth, there was very limited evidence of any significant progress in adopting industrial digital technologies, and this is due to a combination of supply and demand side issues.

First, manufacturing SMEs are constrained by their small smallness manifested through a lack of absorptive capacity. Specifically, a lack of time and relevant knowledge required to understand, adopt and implement Industry 4.0 technologies is holding many manufacturing SMEs back from digitalising their operations. As such, many fail to understand Industry 4.0, the relevance of industrial digital technologies and, critically, how these would add value and fit within their operations. Where attempts to digitalise have been made, a lack of appropriate skills hinders SMEs from taking full advantage of new technologies. An "always done it this way" mentality adds to such constraints of smallness to maintain a perception that Industry 4.0 is something too remote to be concerned about and invest in.

Second, seeing a ROI is the norm across the sector, with the majority unwilling to invest unless a desired ROI can be achieved. SMEs face a real difficulty, or even inability, in demonstrating an accurate and desired ROI from investments in digitalisation. More than that, firms prefer "sweating" existing assets rather than upgrading machinery and adopting industrial digital technologies. On top of that there are fears of unplanned obsolescence of new digital technologies as many expect these to become obsolete at a higher rate than machines. As such, the perceived risk of investment is increased by the uncertainty of a return, leading some to see Industry 4.0 more as an unaffordable cost than an investment with long-term benefits. In this sense, SMEs need to identify clear benefits from investing in Industry 4.0, as while many of the new technologies are desirable, they are still not considered as absolutely necessary but rather as 'wants'.

Critically, adopting Industry 4.0 technologies requires more than a leap of faith for manufacturing SMEs, rather a leap to digital-to-physical processes which cannot be realised without the basics of digitalisation. Not only are manufacturing SMEs lagging being employing advanced digital technologies to analyse data from operations, but for many the physical-to-digital part of the loop is absent. Adopting digital technologies to capture and use data from operations is therefore the first step that the majority of SMEs need to take before being able to even consider the adoption of more advanced technologies. Efforts to close the Industry 4.0 loop will achieve little in advancing the diffusion of industrial technologies in SMEs as long as a physical-to-digital gap continues to exist.

Finally, on the supply side, a disconnect between technology suppliers and SMEs makes existing Industry 4.0 technology offerings of little relevance to the majority of SMEs. A focus on serving market leaders and developing fancier technologies as opposed to practical solutions that address current gaps and SME needs highlights a disengagement between technology suppliers and manufacturing SMEs. Coupled with a lack of trust in technology suppliers and the lack of understanding of new technologies, this serves to erode SMEs' confidence in industrial digital technologies and keeps adoption levels low. Importantly, there is a need for more proofs of concept for SME-oriented technologies and real-life examples of how Industry 4.0 technologies work in an SME manufacturing environment to demonstrate the benefits and viability of such an investment.

That said, those businesses that are able to embrace Industry 4.0 will be key to making UK manufacturing smarter and achieving the vision for the UK to become a global leader in industrial digitalisation. Realising the power and value of data by adopting technologies that enable the capture and use of data from operations will also be essential. It is noteworthy that, while many of the very largest manufacturing firms are investing in and adopting industrial digital technologies, thereby driving progress in Industry 4.0, manufacturing SMEs are under-investing or not investing at all. Compared to some of their larger counterparts in the sector, this poses a relative liability of smallness that adds to the risk of investing in Industry 4.0 for SMEs. The funding made available through the Industrial Strategy Challenge Fund and the Manufacturing Made Smarter initiative therefore presents a real opportunity to increase the capacity of manufacturing SMEs by providing a catalyst to technology adoption and diffusion.

## RECOMMENDATIONS

The backdrop of this report is the future competitiveness and productivity of the UK economy. Given the strategic importance of manufacturing to the UK, it is essential that the manufacturing sector addresses the barriers to digitalisation facing manufacturing SMEs to make Industry 4.0 accessible to 'the 99%' and unlock the potential of digitalisation to drive productivity gains. Clearly the Industrial Strategy Challenge Fund and the Made Smarter funding competitions represent important mechanism to deliver this. However, it also requires closer collaboration between Industry 4.0 technology suppliers and SMEs to develop appropriate solutions, close existing technological gaps, and increase the readiness of the sector for a digitalised manufacturing world.

Based on the evidence drawn from our analysis, there are a number of recommendations that manufacturing SMEs should consider. These are to:

1. *Explore and identify where digital technologies can add value to their operations, and how available data could and should be utilised.*
2. *Invest in the appropriate capabilities (human and physical) in order to effectively adopt and implement digital technologies in the manufacturing process.*
3. *Engage with innovation agencies and intermediaries, such as Innovate UK, the KTN and the Catapult network, to develop innovation capabilities for growth.*

There is also scope for national and local Government, and agencies thereof, to simulate and support digitalisation in manufacturing SMEs by:

1. *Better communicating existing funding opportunities and support available to businesses e.g. via Growth Hubs, KTN, etc.*
2. *Enhancing the outreach and engagement capacity of innovation agencies and intermediaries to educate and support firms to understand and adopt Industry 4.0 technologies.*
3. *Supporting the development of 'regional' digital demonstrators and testbeds to enable SMEs to access and engage with Industry 4.0 technologies.*
4. *Incentivising manufacturing SMEs to adopt and invest in digital technologies through access to funding and finance.*

It is also essential to facilitate engagement and communication between Industry 4.0 technology suppliers and manufacturing SMEs to support the development of solutions tailored to the needs of SMEs. In the case of technology suppliers, offering trial periods for their products and services can help incentivise manufacturing SMEs to adopt technology and facilitate a better understanding of the benefits of Industry 4.0. This can be assisted by government through mechanisms such as networking events between technology suppliers and SMEs as well as 'taster' grants to try out new technologies.



# AFTERWORD

About five years ago we started to hear a new wave of excitement about “Industry 4.0” (or “the fourth industrial revolution”). Through our engagement with SMEs, the KTN identified the need to engage with and support SMEs with impartial advice to understand and adopt digital technologies via the 4Manufacturing® platform. By breaking down Industry 4.0 into key themes and discussing opportunities with a trained advisor, the 4Manufacturing® platform has seen a growing number of businesses benefit and build confidence to tackle more of the themes (for more detail see <https://www.4manufacturing.co.uk/>).

In parallel, the industry-led Made Smarter review published in October 2017 (<https://www.gov.uk/government/publications/made-smarter-review>) that was supported by the KTN put forward recommendations to government about the future of manufacturing in the UK. The Made Smarter review highlighted the importance of cultural factors such as leadership, in driving the adoption of technology, and now the KTN is working to support BEIS, Innovate UK and other stakeholders as they look to put the recommendations into practice.

It has been the experience of the KTN that technology is rarely the right starting point with Industry 4.0. Starting a business engagement with the premise that “technology is the answer” does not drive so nearly an effective discussion as the question “what are your challenges and opportunities”. Given the breadth of the “fourth industrial revolution”, and scale of the opportunity, there is a great deal going on nationally, regionally and locally.

The remit of the KTN is to join things up and share the latest developments, so register for our newsletter and watch out for the latest announcements for regional events and funding opportunities (<https://ktn-uk.co.uk/newsletter>).



**Ben Peace**  
*Head of Manufacturing*  
KTN



## REFERENCES

1. Lasi, H., Fettke, P., Kemper, H.G., Feld, T. and Hoffmann, M. (2014). *Industry 4.0. Business & Information Systems Engineering*, 6(4), 239–242, Available online at: <https://doi.org/10.1007/s1259>
2. Hervas-Oliver, J.L., Estelles-Miguel, S., Mallol-Gasch, G. and Boix-Palomero, J. (2019). A place-based policy for promoting Industry 4.0: the case of the Castellon ceramic tile district. *European Planning Studies*, 27(9), 1838–1856, Available online at: <https://doi.org/10.1080/09654313.2019.1642855>
3. Lasi et al (2014)
4. Deloitte (2017). Forces of change: Industry 4.0. Available online at: [https://www2.deloitte.com/content/dam/insights/us/articles/4323\\_Forces-of-change/4323\\_Forces-of-change\\_Ind4-0.pdf](https://www2.deloitte.com/content/dam/insights/us/articles/4323_Forces-of-change/4323_Forces-of-change_Ind4-0.pdf)
5. Lee, J., Davari, H., Singh, J. and Pandhare, V. (2018). Industrial Artificial Intelligence for industry 4.0-based manufacturing systems. *Manufacturing Letters*, 18, 20–23, Available online at: <https://doi.org/10.1016/j.mfglet.2018.09.002>
6. Deloitte (2017), p.3
7. Lasi et al (2014)
8. Deloitte (2017), p.2
9. Mack-Smith, D., Lewis, J., Bradshaw, M. and Brown, D. (2016). State of Digitisation in UK Business. Available online at: [http://www.sqw.co.uk/files/3714/7282/6880/SQW\\_2016\\_Digitisation\\_productivity\\_report.pdf](http://www.sqw.co.uk/files/3714/7282/6880/SQW_2016_Digitisation_productivity_report.pdf)
10. House of Commons (2018). Business Statistics. Briefing Paper No. 06152.
11. IoD (2018). Lifting the Long Tail: The productivity challenge through the eyes of small business leaders. Institute of Directors. Available online at: <https://www.iod.com/Portals/0/PDFs/Campaigns%20and%20Reports/Economy/Lifting-the-long-tail.pdf?ver=2018-10-10-101825-427>
12. MADE SMARTER Review (2017). Available online at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/655570/20171027\\_MadeSmarter\\_FINAL\\_DIGITAL.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/655570/20171027_MadeSmarter_FINAL_DIGITAL.pdf)
13. Cohen, W.M. and Levinthal, D.A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128-152, p. 128
14. Beaver, G., and Prince, C. (2004). Management, strategy and policy in the UK small business sector: a critical review. *Journal of Small Business and Enterprise Development*, 11, 34–49.
15. Filson, A. and Lewis, A. (2000). Cultural issues in implementing changes to new product development process in a small to medium sized enterprise (SME). *Journal of Engineering Design*, 11(2), 149–157, Available online at: <https://doi.org/10.1080/09544820050034240>
16. Hervas-Oliver et al (2019)
17. Lee et al (2018)

# **DIFFUSING INDUSTRY 4.0**

**Understanding Barriers to  
Digitalisation in Manufacturing SMEs**