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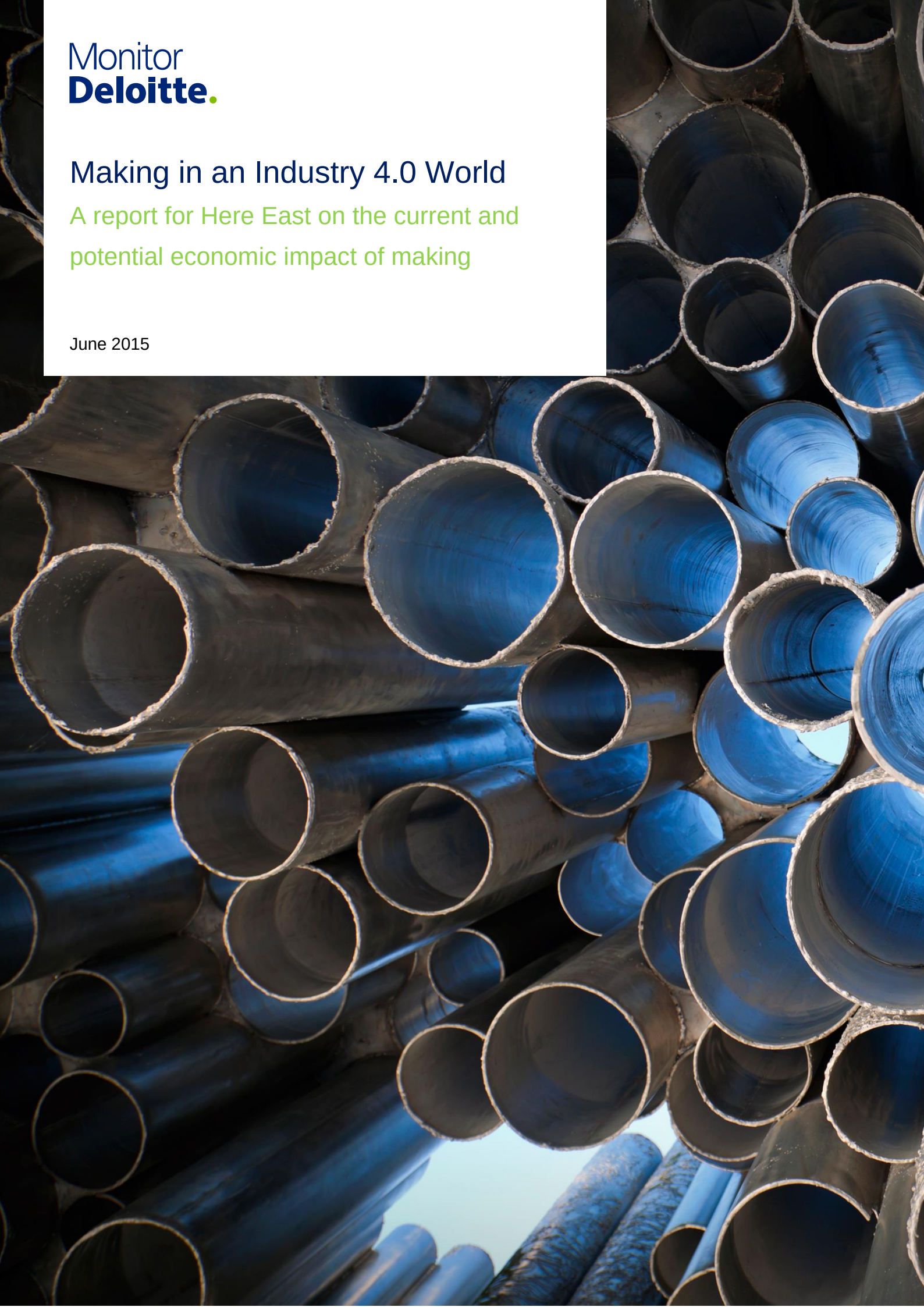
Making in an Industry 4.0 World

A report for Here East on the current and potential economic impact of making

June 2015



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Making on a page

Overall, it is estimated that next generation making activities generate **between £15.6 and £18.1 billion in GVA** for the UK economy, supporting **between 256 and 298 thousand jobs**…

Direct	Indirect	**Total**
134k jobs	122k to 164k jobs	**256k to 298k jobs**
£9.6bn GVA	£6.0bn to £8.5bn GVA	**£15.6bn to £18.1bn GVA**

… and in London alone making activities generate between **£1.8 and £1.9 billion in GVA**, supporting **between 28 and 30 thousand jobs**

Direct	Indirect	**Total**
22k jobs	6k to 8k jobs	**28k to 30k jobs**
£1.4bn GVA	£0.4bn to £0.5bn GVA	**£1.8bn to £1.9bn GVA**

This making process differs from 'classical' making through:

Consumer focus and personalisation

Offering products as platforms

Shorter Value Chains

New and democratised technologies

Greater collaboration

Design-led making

Rapid prototyping

Constant iteration

Makers are present in wide range of industries throughout the UK…

Construction

27% of making jobs

Architecture and Engineering

14% of making jobs

Computer programming

5% of making jobs

… and are **significantly more productive** than other professions

UK maker productivity:	UK average productivity:
£72,200	**£47,700**

+ 51%

London making productivity	London average productivity:
£87,800	**£66,000**

+ 33%

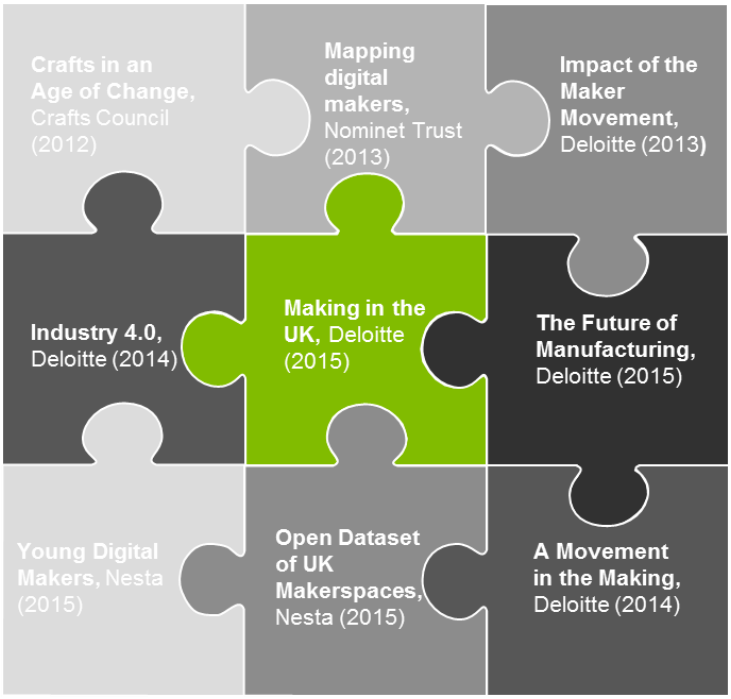
Executive Summary

- Mankind has been making for millennia: making refers to the creation of tangible objects and intangible services and ideas across a range of sectors that generate value – everyone can be a maker
- The classic making journey of producing a contained output is being disrupted by four fundamental shifts caused by technology affecting business as usual:
  - The nature of demand is evolving: customers are seeking much greater customisation and personalisation of products and services, becoming more accustomed to 'freemium' models of purchase, and in many cases are becoming co-creators in the production of value
  - The nature and consumption of products and services is evolving: physical products are getting smarter, more responsive and intelligent, with the ability to control other products; at the same time other products are turning into platforms that generate insights and which consumers can 'hack' and redesign to extract new types of value
  - The economies of production are no longer the same: the convergence and combination of technologies such as additive manufacturing (e.g. 3-D printing), robotics, new materials, biotechnologies, the internet of things, and others is radically expanding the art of the possible and reducing barriers to entry
  - The traditional economics of distribution are breaking down: the distinction between producer and retailer is blurring, reducing the need for intermediaries; at the same time supply chains and inventories are being reimagined and re-located
- The impact of these trends is already being seen with the growth of making communities that are characterised by a spirit of collaboration, a willingness to experiment and fail, a desire to continually iterate and improve and a focus on design-led making – this is the next generation of making, which takes advantage of the above shifts
- This new breed of 'makers', who share an ability to both take advantage of these fundamental shifts and share common attitudes around collaboration and experimentation, can be found in multinationals and niche suppliers across all sectors developing new products and services that better meet customers' needs and addressing 'wicked' problems
- The benefits to the economy of this new making are commonly held: greater making can stimulate productivity through enhanced skills, greater innovation, more competition and enterprise and by encouraging investment – this in turn, can drive economic growth and prosperity
- More widely, making benefits society by stimulating curiosity, helping to foster more local working and production and it can also lead to a reduction in the environmental footprint
- However, despite the importance of making and its benefits, conventional statistical measures do not typically measure its contribution or size – this makes it hard for policymakers and private sector supporters to effectively identify interventions to promote and support making in the UK
- This research has, for the first time, begun to quantify the economic contribution of making in the UK and London specifically. On a conservative set of assumptions, it is estimated that making supported 134,000 jobs directly and between 122,000 - 164,000 in the associated supply chain in 2015 in the UK; making contributed to between £15.5-£18 billion in GVA to the UK annually
- Of this figure, 22,200 direct jobs and 5,700- 7,600 supply jobs are in London and nearly £2.4 billion GVA was generated in London
- The productivity per worker of those directly involved in making (on the definition used) was higher than the UK all industry average: £72,000 versus £47,700
- Based on stakeholders discussions, the contribution of making to the UK economy and society is expected to grow significantly, increasing the UK's competitiveness globally and creating demand for more high-skilled jobs
- However, for this future contribution to be achieved, a number of existing constraints on growth will need to be addressed – these include resolving challenges around organisations having access to the right skills, finance, infrastructure and information to allow businesses and products to scale quickly, by demonstrating their potential and crafting business cases for investment. There is also a major role for convenors in developing a making ecosystem that provides support in a coherent and effective manner.

Scope of research

Deloitte has been commissioned by Here East to undertake independent research to add to the growing evidence base on the role of making to the UK economy. In particular, over the course of five weeks, Deloitte has collected primary and secondary evidence in order to quantify the economic contribution of making in the UK and London in terms of jobs and Gross Value Added[1]. The research has also considered the wider benefits of making to the economy and society and the challenges to ensuring the UK achieves its full potential with respect to making.

Figure 1: Research on Making



Source: Deloitte analysis

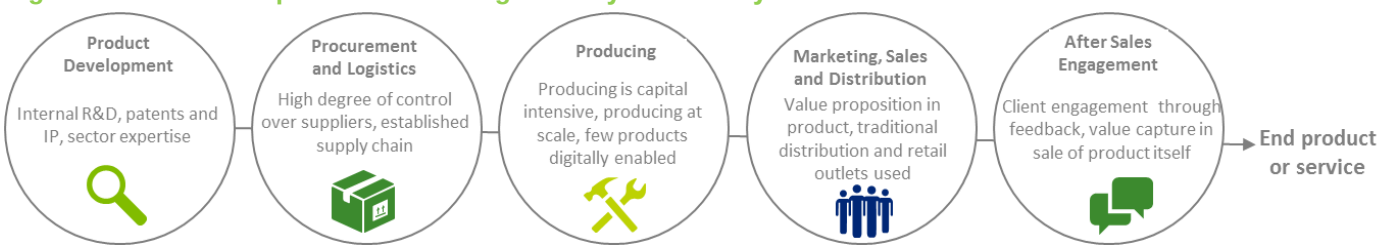
What is making?

Making is a broad term and refers to **the process of creating outputs from a set of inputs**. It is **an inherently creative process** which people from across the world have been doing for millennia, often motivated by a desire to solve a particular problem or create something new.

Using this definition, **anyone can be a maker** – it is not restricted to large-scale manufacturing or small-scale arts and crafts. Those involved in making can come from all parts of society: from industry experts to self-taught entrepreneurs; from small-scale start-ups to established multinationals with decades of history. Importantly, **the output of making does not have to involve a physical product** – the outputs can be as diverse as a tangible product like a car or something less tangible such as piece of downloadable software with no direct physical footprint

Classically**, the process of making has been thought of linearly with a number of distinguishable steps**, as inputs are turned into outputs by those involved in making for the benefit of end-users (customers).

Figure 2: The classic process of making in today's economy



Source: Deloitte analysis

[1] GVA can be thought of as analogous to GDP. All figures calculated in this research are based on a series of modelling assumptions and the available data – if either of these were to change, the calculations would be impacted.

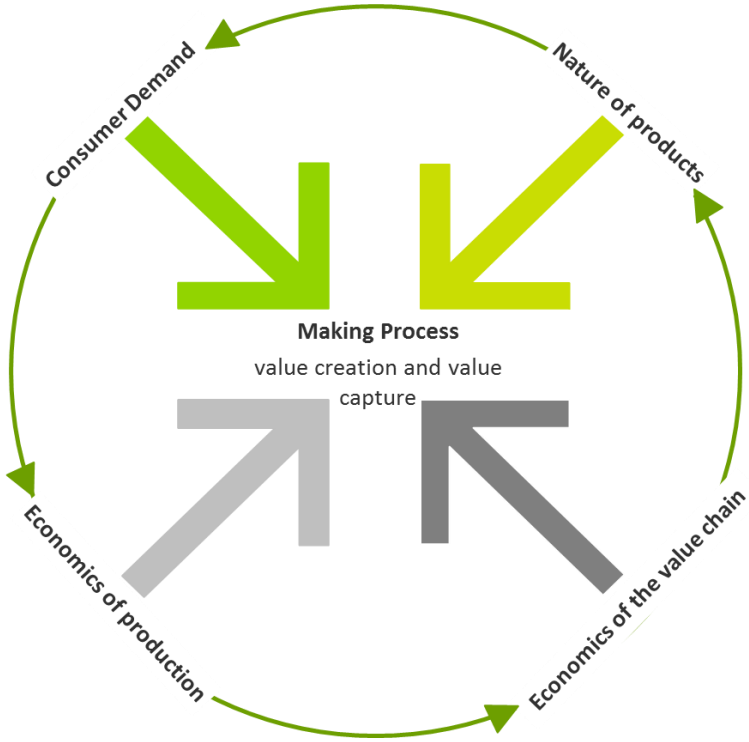
The classical process of making is largely sequential and consists of a development phase before moving towards manufacturing and distribution, and finally consumption. Regardless of the sector and nature of the output, **value is embedded into the output, and consumed at the end of the process.**

The classical process of making has itself evolved over time to harness new technologies, production techniques and means of distribution. It itself is an agile process and not inimical to change. However, in recent years a number of technological, economic and societal forces have converged to radically disrupt the classical process of making, adding a significant degree of non-linearity to the process of making and changing the nature of how value is being generated and consumed.

What's changed?

Research has identified the ways in which rapid technological change and convergence are creating **four fundamental ways in which making is being disrupted**. This, in turn, can have significant consequences for business as usual across the economy and the creation and capture of value. These shifts are summarised below:

Figure 3: Four Fundamental Shifts Changing the Making Process



Source: Deloitte analysis

- **The nature demand is evolving**: customers themselves are driving change in making; specifically through increasing demand for personalisation (to the individual) and customisation (to the niche market segment); through growing acceptance of new business models such as freemium; and increasing interest in the making process itself, through expressing a desire to shape the product/service it is they purchase;
- T**he nature and consumption of products and services is no longer static**: in addition to well-known trends around products becoming smarter and the internet of things, products and services are increasingly becoming modular and hackable to allow consumers themselves to refine, repurpose and repair them for themselves – this in turn is helping foster greater 'eco-system' thinking where products are defined with respect to each other and continually contextualised to new environments;
- **The economies of production have changed**: the way products and services can be made is rapidly changing; this is most obviously seen in the manufacturing sphere with the rise of exponential technologies such as additive manufacture, robotics and AI, nanotechnology, new materials and biotechnologies, and so on – many of these technologies can help reduce carbon footprints and can help re-source making processes closer to the point of consumption; as well as altering the making process, these technologies are also helping reduce barriers to entry and expansion; and
- **The traditional economics of distribution are breaking down**: producers can now easily have a direct sales relationship with customers, and customers themselves are moving towards having much greater affinity to

businesses over products; at the same time supply chains and inventories are being reimagined and re-located, often back to the developed world.

Figure 4: Examples of changes in making in action

Bare Conductive

- Bare Conductive produces electric paint that can connect any surface or object to the digital world.
- The product was developed through a fail-fast process in which the founders went through a bottom-up process of "making, testing, tweaking, and re-making" until they had a proof of concept.
- The paint is a product in itself, but also a platform that allows users to add value and define their own end use for the product.

Knyttan

- Knyttan developed software that directly links fashion designers digital clothing designs and specifications to industrial knitting machines, eliminating the need for extensive code to be written to produce each garment.
- The platform creates opportunities for designers to offer their products directly to consumers at zero cost, which otherwise would not be possible.
- The software has resulted in a streamline, digital production process that in a sector whose output is still very physical in nature.

MakieLab

- MakieLab uses an online platform, which allows customers to design individualised dolls and produces each doll using powered nylon in 3D printers.
- Allowing people to design the product they purchase challenges the traditional role of a customer as a consumer, given them an active role in the making process.
- MakieLab embraces a 'learn by doing' attitude, reflected in the product itself and the business model used to design, produce, and sell their products.

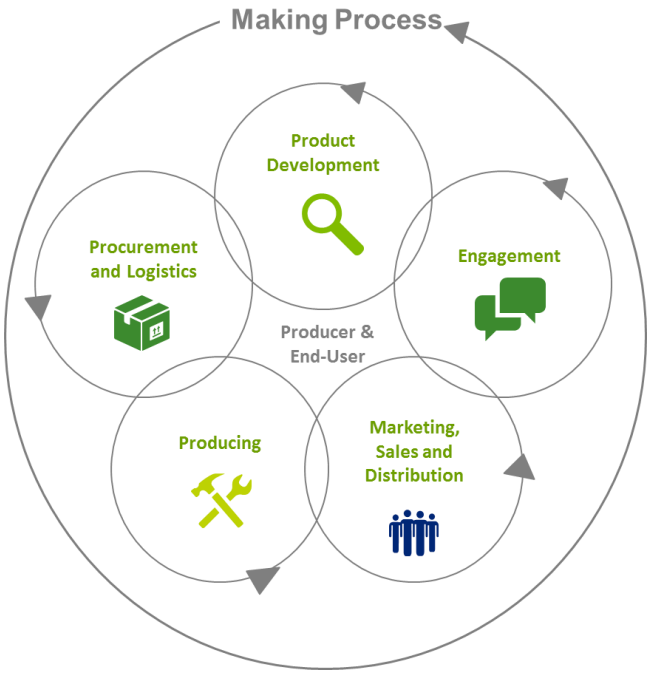
GE FirstBuild

- FirstBuild is a GE subsidiary and the test case for the firm's new manufacturing model – a combined online and physical co-creation community for makers, designers and engineers. It is a system that combines the capabilities of the large manufacturer and a lean start-up.
- GE established FirstBuild after realizing that to build products more quickly, it needed to test more ideas with more people more frequently. It can produce small quantities and discontinue products if unsuccessful, or draw on GE's supply chain to manufacture at high volumes if in demand.

Source: Deloitte analysis and stakeholder discussions

Together, these shifts mean that **value creation is now possible across all stages of the making process and is not a one-off event**; customers can continue to generate value from their relationship with a product/service on an ongoing basis.

Figure 5: Non-linear Making Process



Source: Deloitte analysis

Making is no longer a linear sequential process; it has the potential to have significant non-linear and non-sequential elements and be collaborative and adaptive.

Who's making today?

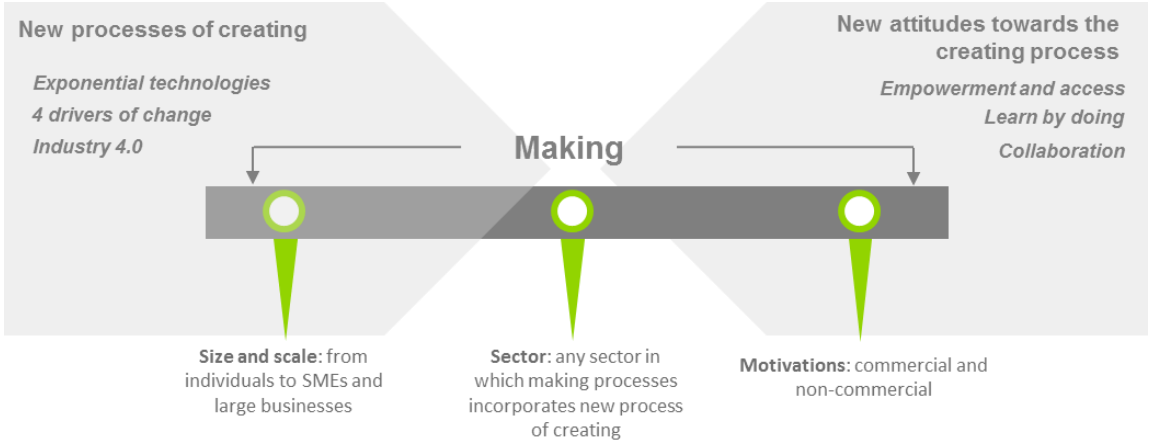
This research has found there to be a large number of individuals and businesses, large and small, taking advantage of these shifts in making. The term Industry 4.0[2] has been used to refer to some of the key changes occurring in the making process. Specifically, **Industry 4.0 refers to a production process that is digitally connected and highly responsive to customers; integrates business partners and customers in a way that creates new business models of cooperation; and uses exponential technology to produce products that are continually being re-engineered and improved**. In this sense, people engaged in making activities are embracing the technologies, attitudes and processes of Industry 4.0.

They often share the characteristics of:

- **Collaboration**: both inside their own industry (either as 'frenemies' or as partners) and with other industries and disciplines – this often manifests itself in designs being available on an open-source basis and costs being shared;
- A focus on **design-led making**;
- A willingness to **rapidly prototype, try new things and not be afraid to fail**; and
- An **ongoing curiosity and desire to improve outputs** and make them more relevant to customers.

It is these individuals and businesses who share an ability to take advantage of these fundamental shifts and hold many of these common attitudes who are the focus of this research. They combine a willingness to innovate and experiment with an ability to harness new technologies and trends to create customer-led products and services.

Figure 6: Characteristics of Making for this report



Source: Deloitte analysis

Those involved in this next generation making can be found across all industries and regions of the UK. However, **existing statistics and measures do not effectively capture this important component of the economy**. This is primarily because making is a process and as such is not easily captured in national statistics as it does not comfortably sit in one sector or another, or fit within existing product typologies. Those involved in making also span multiple sectors, types of businesses and are also sometimes self-employed. Further, the characteristics or attitudes of those involved in the next generation of making are likely to be underrepresented in surveys or traditional indicators for innovation or R&D.

However, these limitations notwithstanding, Deloitte has sought to create the first measure of the size of making workforce in the UK. Using existing statistics on Standard Occupation Classifications (SOC), calibrated through discussions with stakeholders, the research has estimated the proportion of 'makers' in all sectors of the economy.[3] Occupations associated with making include engineering, design and development, scientific researchers,

[2] As noted in Deloitte (2014), Industry 4.0, the term is widely used across Europe, particularly Germany, as well as in the United States.

[3] This is a total of 615 sectors at the four digit SIC code level.

researchers and information, communications and software professionals[4]. Using these calibrated assumptions, the following annual job estimates have been calculated for those involving in making (as defined above)[5]:

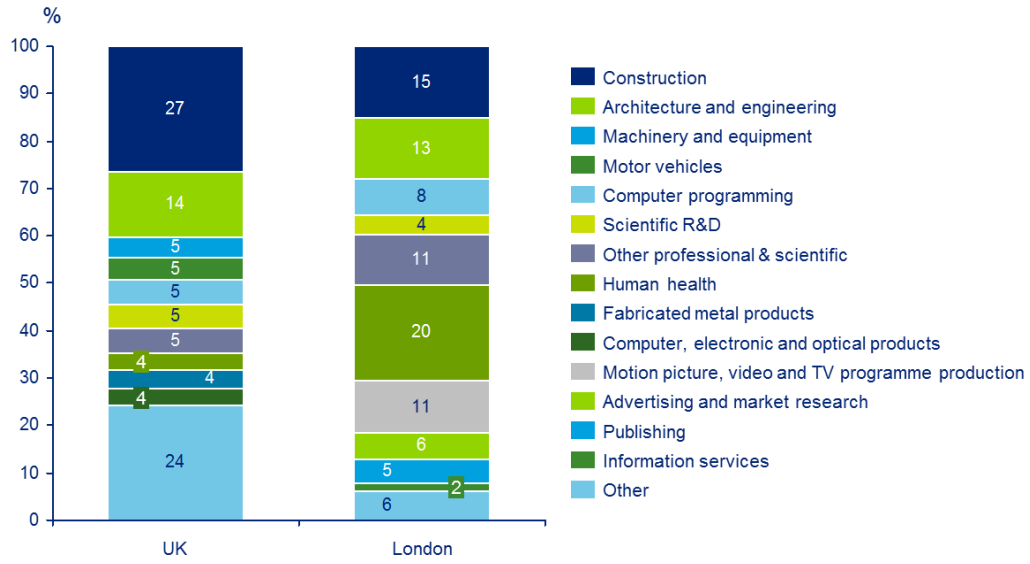
Figure 7: Direct jobs in making in the UK and London

	Direct Jobs
London	22,200
Total UK	134,000

Source: Deloitte analysis

It is estimated that nearly 20 per cent of all making jobs in the UK can be found in London. Compared to all London jobs as a proportion of total UK jobs (19 per cent), making activities are slightly more concentrated in the capital.

Figure 8: Top Ten Making Sectors, UK and London, % of all makers



Source: Deloitte analysis

It can be observed that at UK level, making is spread across a wide range of sectors. The largest proportion of active making jobs are estimated to be in construction (27% of UK making jobs) and architectural and engineering (14% of UK making jobs). Advanced manufacturing sectors such as machinery, motor vehicles and fabricated metal are also amongst the top 10 sectors in the UK. At the London level however, there is a much higher concentration of making jobs in the creative industries: motion picture, video and TV programme production (11%), advertising (6%) and publishing (5%) all within the top 10 sectors.

What is the contribution of making to the UK economy?

The above estimates refer to direct jobs only, i.e. those working in jobs directly associated with making. However, the economic contribution of making goes beyond those directly involved in creating products and services – **there will be a supply chain involved that relies on making jobs**. Using the direct jobs estimates, the research has estimated the supply chain jobs supported by making activities (as defined above).

Figure 1-9 Total number of jobs involved in making today, London and UK

	Direct Jobs	Supply Chain Jobs	Total
London	22,200	5,700 - 7,700	27,900 - 29,900
UK	134,000	121,700 - 164,000	255,500 - 298,000

Source: Deloitte analysis

[4] A full list is placed in the methodological appendix.

[5] Further scenario and sensitivity analyses are presented in the main text of the report.

Based on the sectors in which making is taking place, the **productivity per worker in making activities is above average, at both the London and UK level.** In London, productivity per worker in making activities is £87,800 compared to £66,000[6], while in the UK it is £72,000 compared to £47,700.

The overall economic contribution of all those involved in making (directly or in the supply chain) can be estimated through the GVA attributable to them. Based on the estimated number of direct jobs participating in making activities today, it is estimated that **direct making activities generate £1,400m GVA in London and £9,600m GVA in the UK as a whole. When the GVA supported through the supply chain is included, these figures rise to £1,800m for London and £18,100m in the UK.**

Figure 1-10 Total GVA generated by making activities today (£millions), London and UK

	Direct GVA	Supply Chain GVA	Total (£millions)
London	£1,400	£400 - £500	£1,800 - £1,900
UK	£9,600	£6,000 - £8,500	£15,600 - £18,100

Source: Deloitte Analysis

While making activities generate a direct economic impact in terms of jobs and GVA, they also **generate wider benefits for UK productivity, which is fundamental to the long-term growth and sustainability of the economy**. Productivity is a key economic output that drives value creation in the economy and making activities drive productivity through their wider impact on skills, innovation, enterprise, investment and competition. Making activities represent a significant opportunity to contribute to the rise in productivity the UK must achieve, namely through:

- **Skills**: making activities are already influencing formal education for young people as well as cultivating a culture of lifelong learning and experimentation. Making activities are raising awareness about the importance of experiential learning or learning by doing, as well as the need for students to develop digital skills from a young age. Furthermore, products that are emerging from making activities are designed in a way that facilitates the user learning about its underlying technologies. **Creating a culture of learning and exploration can increase human capital, which in turn can drive productivity.**
- **Innovation**: the process of creating something new of economic value, or innovation, is supported by making activities in multiple ways. Not only do the exponential technologies used allow for new production methods and products to be created, but they also allow existing technologies to be applied which couldn't before. **This can help lower costs and improve competitiveness – which will drive productivity.**
- **Investment**: making activities of businesses, from SMEs to large businesses, are attracting investment and growing new types of finance which previously did not exist in the UK. **As businesses and individuals use the latest technologies that can expand their capacity to create and can also increase scale, which in turn can lead to economies of scale and scope which raises productivity.**
- **Competition**: making activities are increasing competition in the economy due to the reduction in barriers to learning, commercialisation and finance. This can introduce new players to the market who can generate new competitive pressures on incumbents putting pressure on prices and creating new incentives to innovate and better meet customer needs. For example, the widened application of 3D printing could challenge traditional manufacturers by drastically cutting the delivery times that customers come to expect, forcing such manufacturers to reduce their time to market in order to remain competitive – ultimately benefitting customers for both types of product. **This can also serve to increase productivity as businesses are forced to become more efficient.**
- **Enterprise**: similar to making activities' impact on competition, the reduced barriers to entry combined with the empowerment of individuals through democratised technologies is allowing people to commercialise ideas which otherwise would unlikely be possible. **A culture of not being afraid to fail and more risk taking can also lead to more innovation, which again drives productivity.**

[6] London productivity per worker figure has been adjusted from national data to account for higher productivity in the city

Maximising the making opportunity in the UK

Based on stakeholder discussions, **it is commonly held that the contribution of making to the UK economy and society can grow significantly, increasing the UK's competitiveness globally and creating demand for more high-skilled jobs**.

However, for this future contribution to be achieved, a number of existing constraints on growth will need to be addressed – these include **improving organisations' access to the right skills and finance**, **challenging risk-averse cultures**, and **addressing infrastructure and information gaps in order to allow businesses and products to scale quickly.** There is also a role for convenors in developing a making ecosystem that provides support in a coherent and effective manner.

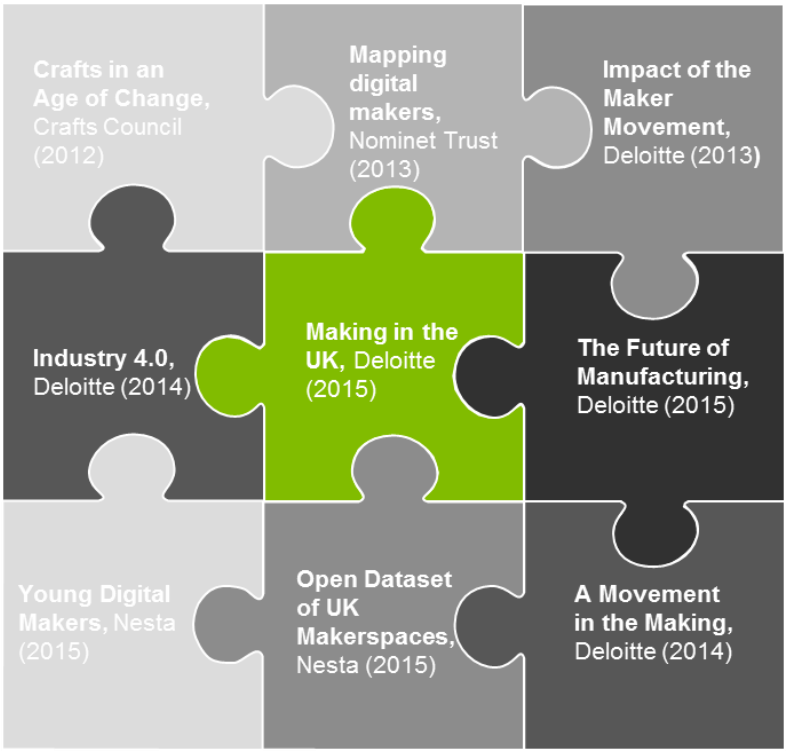
1 Introduction

1.1 Study scope

Deloitte has been commissioned by Here East to undertake research to contribute to the growing evidence base on the role of making[7] to the UK economy. In particular, over the course of five weeks in April and May 2015, Deloitte has collected primary and secondary evidence in order to quantify the economic contribution of making in the UK and London in terms of jobs and Gross Value Added and highlight case studies where making is taking place. The research has also considered the wider benefits of making to the economy and society and the challenges to ensuring the UK achieves its full potential with respect to making in the future.

This research complements other work on making by a number of other organisations.

Figure 1-1 Relationship with other research



Source: Deloitte analysis

Other research exercises have focused on particular dimensions of making (or more specifically digital making). For example, Nesta, has studied 'digital making' in the context of digital skills, digital literacy, and digital creativity.[8] Similarly, the Nominet Trust has undertaken research to identify four dimensions[9] to digital making that set it apart from the traditional making and creating activities that have always occurred.

[7] The term 'making' is used for a specific set of processes and attitudes in this report – see Chapter 2 for a full definition.

[8] Nesta (2015), *Young digital makers: surveying attitudes and opportunities for digital creativity across the UK*. **http://www.nesta.org.uk/sites/default/files/young-digital-makers-march-2015.pdf**

[9] Nominet website, accessed 7th May 2015 **www.nominettrust.org.uk/knowledge-centre/articles/mapping-digital-makers**. The four dimensions referred to are:

1. Digital medium: refers to imagining, designing, developing or building and then sharing products that are digital in nature, therefore relying on businesses of computational thinking such as coding.
2. Transferring other mediums to digital: recognises that much digital creativity means making and sharing products whose origins lie in another medium, such as writing and music.
3. Sharing and communication: the digital medium creates new opportunities for increased information transfer to occur during the creating process.
4. Learning to make: the process of learning how to make has been transformed by existing making communities.

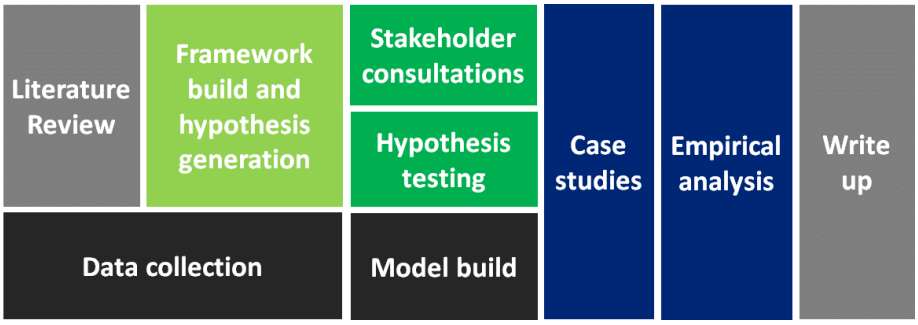
This research on making builds on the work of Nesta and Nominet by reflecting the attitudes of digital making but linking these activities to wider industrial transformations. It places making at the centre of both industrial and social change, harnessing technological improvements, and recognising that making is not so much a movement along the side-lines of the UK economy or in each niches, but that making is at the centre of the nation's economy.

Together, these pieces of research are creating a much richer understanding of the different dimensions of the making landscape in the UK.

1.2 Study method

This research has comprised of a number of work streams outlined below.

Figure 1-2 Deloitte study methodology



Source: Deloitte

The stakeholders consulted as part of this research included makers themselves, organisations in adjacent markets, researchers in this area and Deloitte sector experts. Deloitte would like to record its thanks to each organisation for its time and participation.

1.3 Limitations

The analysis contained in this report is largely based on publicly available research and data. Given the nature and novelty of the research, the quality and quantity of data available on making has been severely limited. Accordingly, all empirical estimates have been heavily informed by modelling assumptions based on the available information and stakeholder feedback – all empirical estimates of the contribution of making in terms of jobs, GVA and productivity should be treated as indicative. Should these assumptions change, the estimates may be substantially revised. As this is an emerging field of research, one would expect subsequent study to refine the numbers presented in light of more, and better, data.

2 What is making?

Key insights

1. **The 'traditional' business model common is based on a linear process of making, which comprises a set of sequential steps from research and development to production, distribution and sales. The relationship between producer, intermediary and consumer is largely transactional with value being generated at the end of the process through the consumption of a pre-defined product or service.**
2. **Several shifts in the making process are occurring which are disrupting business as usual, both on the supply and the demand side.**
3. **Consumer demand is changing the nature of products and services as those involved in making are incentivised to create 'unlocked' outputs that consumers can repair, continue to adapt and refine to generate a stream of ongoing value that can grow. The Internet of Things is transforming the potential of products.**
4. **Exponential technologies, coupled with online learning platforms and new forms of finance have empowered individuals and start-ups to enter markets they previously would not be able to compete in due to lack of knowledge, capital and scale. For large manufacturing businesses these technologies have enabled them to streamline production and rapidly prototype new products.**
5. **The changing economics of distribution are impacting both the role of the intermediary as well as the role producers and consumers – the gap between producer and consumer is narrowing.**
6. **At the same time as changes to making processes, there have been shifts in attitudes with a greater willingness to collaborate, have a design-led approach to making and a desire to fail fast and continually iterate to improve products and services.**
7. **It is those businesses and individuals involved in making that are able to take advantages of changes in making processes and exhibit these new attitudes to making that this research focuses on – what might be termed the next generation of making. This captures a narrower set of activities than the broadest definition.**

This chapter sets out the definition of making used in this research; it then provides context on the changes affecting making which are disrupting business as usual and altering the nature of making and its outputs.

2.1 Defining making

This research uses the term 'making' broadly, defining it as 'the process of putting together inputs to create something new'. Making is therefore, by definition, a creative process which people across the world have been doing since the beginning of time, often with the express purpose of solving a problem or creating something of value (although making can often have no specified end-goal).

Over time, making has become associated with the manufacturing sector. While this is correct, it should be recognised that, as defined in this research, making is broader than manufacturing intermediate and finished products – it is a fundamental process of value generation that takes place across the economy. Those involved in making do not just reside it the manufacturing sector, but can be found in all economic sectors. Today, those who

make covers wide spectrum of demographics: from industry experts to self-taught entrepreneurs; from small start-ups to established multinational businesses; and from app developers to automotive manufacturers.

The products that are being made are equally as diverse as the people making them – they can be physical or virtual, a product or an experience, a finished piece of equipment or an unfinished product to be customised by the user.

Figure 2-1 The broad definition of making used in this research

Making is the process of putting together inputs to create something new.

Its outputs can be tangible objects or non-tangible services or ideas.

Making can occur in any sector of the economy and be done by individuals and businesses and government.

Source: Deloitte

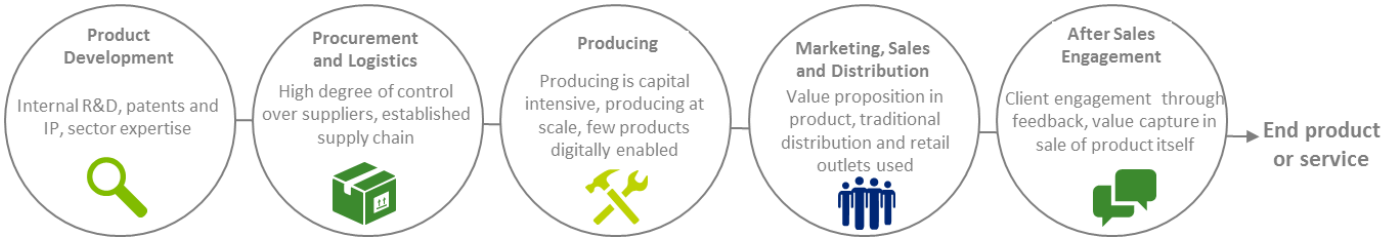
2.2 The 'classic' making process

Making is an inherently dynamic process and has evolved over time responding to technological, societal and environmental changes. It has moved from small-scale production to mass production and distribution and communication of products and ideas that are increasingly complex and automated. While there is no single model of making (as it covers a diversity of industries, individuals and businesses), there are some distinct elements that could be said to characterise the 'classic' making process:

- Linear R&D: traditionally undertaken in-house and understood as a linear process from development to market, with minimal customer engagement with the source of R&D usually internal to a business or from expert industry researchers;
- Long product life cycles: improvements to products and services can be few and far between;
- High barriers to entry: the manufacturing process is capital intensive (or human capital intensive for services) and businesses are required to produce at scale in order for product to be viable;
- Products and services are objects of value: the products and services themselves generate value for users at the point of consumption and there is a clear distinction between the creator and the end consumer.

Thus, the classic business model for making might be said to be based on the value proposition of delivering outputs (products and services) of increasing quality and functionality for lower prices to end users in a linear fashion. This linear journey is shown below where making comprises a structured set of sequential processes beginning with research and development through to production, distribution and sale.

Figure 2-2 Classic process of making



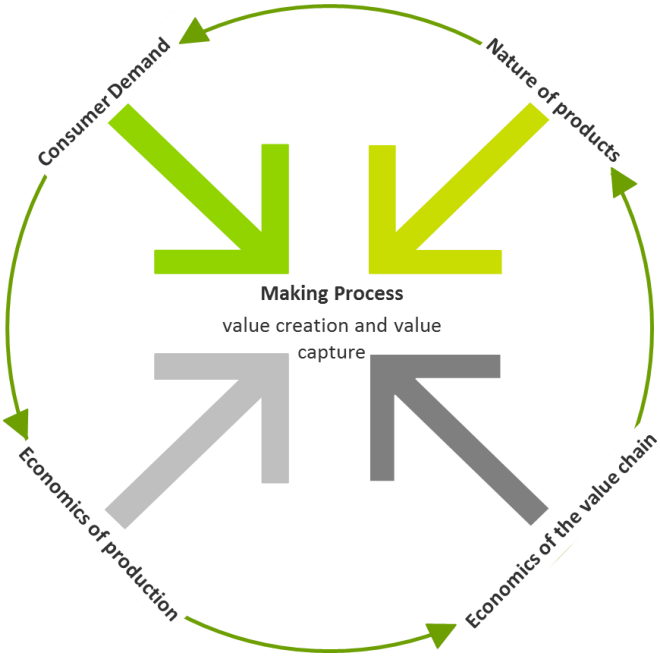
Source: Deloitte analysis

Insight 1: The business model common to making today is based on a linear process of making, which comprises a set of sequential steps from research and development to production, distribution and sales.

The relationship between producer, intermediary and consumer is largely transactional with value being generated at the end of the process through the consumption of the product or service.

2.3 Fundamental changes in to the making process

The classic making process may be thought of as having applied to the twentieth century. However, with rapid technological changes, the making process is being significantly disrupted (or in many cases already has been disrupted). Today, businesses are harnessing new technological techniques and processes to allow each product to be unique and customer specific. They no longer have to mass produce to be financially viable. Supply chains have been streamlined and the making process how now become closer to the consumer, reducing the reliance on intermediary producers, distributors and retailers.



Disruption to the classic making process can be explained by four fundamental changes, which are affecting all types of making from large-scale manufacturing to bespoke service provision. These are changes to: consumer demand, products and services, economies of production and economics of distribution. Ultimately, these changes are combining to affect the way in which businesses and individuals create and capture value from the making process. While individually, each of these shifts have already had impacts on making in the past, it is the convergence of these forces today that is motivating system-wide disruption.

The following sections explain in further detail the drivers of these fundamental changes and how they are shaping a new making process beyond the classic model. This new making process has been dubbed as Industry 4.0.[10] The term typically refers to a production process that is digitally connected and highly responsive to customers; integrates business partners and customers in a way that creates new business models of cooperation; and uses exponential technology to produce products that are continually being re-engineered and improved. While this research leverages the insights from Industry 4.0, it expands it and applies it more generally to all forms of making, not just manufacturing.

Figure 2-3 Case study on Technology Will Save Us: A Technology Business for the Maker Generation

In a world where young people are born with iPads, kids 'mod' Minecraft after school for fun and parents worry about how much screen time is healthy - Technology Will Save Us is on a mission to spark the creative imagination of young people using hands-on technology.

Started in 2012, the firm believes that all young people are curious, creative and fearless but do not have many options to learn and create with technology as they are growing up. The firm aims to empower them with an award winning DIY Gadget Kits that they can make and code themselves, a digital platform with plenty of content focused on making and inventing, as well as supportive materials for parents and educators to feel up-to-speed and confident with the technology their kids are making.

The founders of Technology Will Save Us are aiming to change people's relationship with technology, to take learning off the screen and support people (especially children) to channel their desire to be creative and create to using technology. The product leverages the democratisation of technologies that has occurred: it bridges a gap between people who have access to products such as Arduino but not the knowledge on how the technology can be used.

The company itself has grown significantly since it started. They have sold 30,000 kits in 47 countries; grown from 2 - 18 employees; Their Gamer kit was acquired by the Museum of Modern Art in New York as part of their

[10] As noted in Deloitte (2014), Industry 4.0, the term is widely used across Europe, particularly Germany, as well as in the United States.

permanent collection and shortlisted for designer of the year 2015 by the London Design Museum. The start-up raised £450,000 of seed investment from the chairman of Code Club (Chris Mairs), early investor in Citymapper and YPlan (Gi Fernando) and Saatchinvest, an investment vehicle bakced by M&C Saatchi ad agency. Grant funding has also been raised from the Digital Makers Fund, Google Rise and Innovate UK.

Source: Deloitte analysis based on consultation with Technology Will Save Us founder and Financial Times, *A DIY Tech Evangelist Scales up before BBC's Micro Bit Giveaway*, 6 April 2015

Consumer demand

The changing nature of consumer demand has been evident for some time and continues to exert pressures on making. Specifically, personalisation (to the individual) and customisation (to the niche market segment) have become available to a wider range of consumers, largely due to digital technologies, especially the internet.[11] As a result, there is now a growing number of consumers who are increasingly expecting/demanding products and services tailored to their individual preferences. For example the customers of MakieLab, which can fabricate a doll in line with a customer's exact specifications (see below). While demand for niche products has always existed, it was previously limited to those willing to pay extra for this customisation. Now, it is becoming cost-effective for businesses to satisfy this demand on a large scale. At the same time, it is leading to a more fragmented marketplace with businesses able to thrive by targeting only very specific market segments rather than having a mass-market offering.

Figure 2-4 Case study on MakieLab: The use of 3D printing to make personalised children's toys

MakieLab was established in 2011 and is a business that produces dolls that are 100% designed by each individual consumer. The business has an online platform which allows customers to create their dolls – choosing their hair, eye colour, clothes and more – and prints each doll using powdered nylon in 3D printers. The product produced by MakieLab, as well as the business's business model illustrate several key concepts of the making process.

Customers have access to making process: MakieLab has created a product and production process which is largely dictated by the choices of the customer. Allowing people to design 100% of the product they are purchasing challenges the traditional role of a customer as a consumer, and gives them an active role in the making process. Once a doll is designed, MakieLab supports the continued involvement and access of the customer to the making process by posting photos on Instagram of the production and packaging of each customer's unique doll. This reflects the growing trend in consumer demand to have access and ownership over how products are made.

New application of existing technology: The Makie dolls themselves represent a fundamental principle of making today, which is that new technologies can be applied in ways which they have never been used before, changing traditional ways of making. In this case, 3D printing has been applied to a range of sectors and used for prototyping to production of component parts, but never had it been used to produce a children's toy. To do so was possible but required a significant amount of learning and collaboration with others to bring the idea to life and make it operational.

End-to-end value chain platform: MakieLab controls all processes along the value chain, from the online platform that customers use to design their doll, to printing the dolls on in-house desktop 3D printers, to the sales and customer service. MakieLab highlighted that there were several reasons why they have chosen to keep these processes in house. Not only would it be difficult to outsource a process which no one has ever done before but MakieLab embraces a 'learn by doing' attitude. This attitude is reflected in the product itself, in which the founders had no experience with neither toy making nor additive manufacturing. However this desire to learn by doing remains, as the business is keen to continue learning from and refining their business by controlling its operations in-house.

Source: Deloitte analysis and stakeholder discussions

[11] Deloitte Center for the Edge (2015), *The future of manufacturing: Making things in a changing world.* **http://www2.deloitte.com/content/dam/Deloitte/za/Documents/manufacturing/ZA_Future_of_Manufacturing_2015.pdf**

A further change in the nature of consumer demand has been the growing interest in the production process and an increasing desire by consumers to be involved in the creation of the product and service they will ultimately purchase. While the former trends continues consumers' desire to have more sustainable, ethical making, the latter trend reflects the opening up of the making process to involve consumers as well as producers. Each of the businesses which are the subject of a case study in this section offer customers either the ability to customise their order to a high degree, or provide a product that empowers the customer to engage in the customisation process themselves by shaping or working with the product once it is in their possession.

The desire of consumers to become involved in the creation of the products they consumer is not limited to the production process. It is also manifesting itself through crowdfunding platforms, where consumers can support ideas and businesses they connect with, as well as in the research and development process, where consumers have a voice in deciding future product designs.

This is affecting B2B as well as B2C businesses. For example, manufacturers of aerospace engines are now digitally connecting and sharing information between their internal R&D teams and external suppliers through software such as Team Centre, facilitating responsiveness throughout the entire production process.

Insight 2: As a result of increased consumer demand for customisation and personalisation, several shifts in the making process have occurred. Businesses have found it is now financially viable to making niche products catering to specific segments of the market.

In addition, the making process has become increasingly open and responsive to rapidly changing customer demand. This can manifest itself in various ways from a digitally connected production process to online platforms that allow customers to play an active role in designing the product.

Nature of products and services

The nature of making outputs is also changing. Products and services are no longer 'locked' objects that can only be used for a single purpose for which they were designed. Products and services are increasingly becoming platforms that deliver an experience and are open to being adapted for a variety of uses. This 'product as a platform' scenario, where individuals can create solutions that unlock further value from existing products – by creating a smartphone application for example – allows for experimentation and creates a large follow-on market of potential customers and producers. This is most obviously seen in software development where the rise of the open source movement allows for users to customise and adapt products on an ongoing basis; but it is also happening in other sectors as illustrated below. Other specific examples include businesses like Bare Conductive and Sugru, which offer materials that allow customers to undertake the final step in the design process, crafting the products into a final product of their choosing.

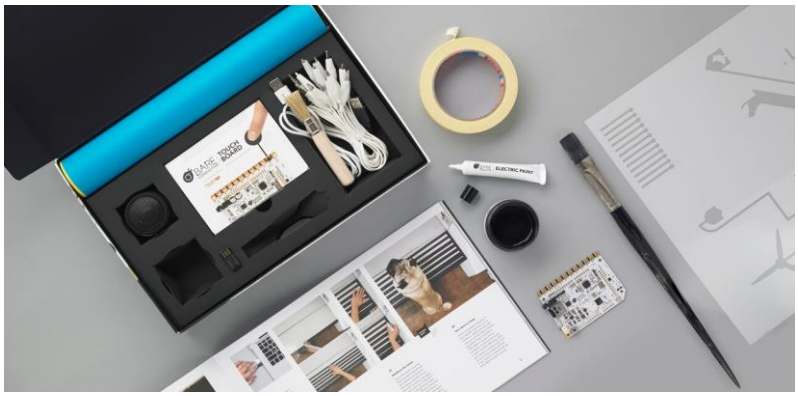
Figure 2-5 Case study on Bare Conductive: Electric paint that can connect any surface or objective to the digital world

Bare Conductive is a business that spun out of a thesis project in industrial design and engineering. Today, the business produces three products: electrically conductive paint that can turn any surface or object into a sensor; a piece of hardware, the Touch Board, which converts the sensor data into sound, light or data; and kits geared towards focused project outcomes using these platforms. A number of aspects of the business reflect new changes to the making process.

Fast-fail and learn by doing: The way in which Bare Conductive developed the concept of Electric Paint and commercialised this product is very reflective of the new making process. As described by the business themselves, the founders went through a bottom-up process of "making, testing, tweaking, and re-making" until they had a proof of concept. To move from proof of concept to actually making their idea a reality, they reached out to a range of specialists, from chemical manufacturers and chemical engineers to patent lawyers.

Products as platforms: Bare Conductive's Electric Paint is a product in itself, but also a platform that allows users to add value and define their own end use for the product. In this sense, the product is half-finished and ultimately empowers the user to develop their own customised solutions using the paint and hardware.

Customer learning: While the product itself facilitates the empowerment and learning of the end-users since the technology can be applied in a myriad ways, Bare Conductive's business model also supports collaboration and learning amongst product users. Their website allows users to upload tutorials on how they have applied the technology to a specific use. This could range from how to make touchscreen gloves, to interactive greeting cards, to how to fix a computer keyboard with electric paint. Ultimately, the product as well as the business itself is facilitating learning by doing, collaboration and sharing amongst users, and is serving as a platform for these interactions to happen.



Source: Deloitte analysis and stakeholder discussions

Further, products are becoming smarter and more responsive. The expansion of sensors and digital connectivity, falling under the banner of the Internet of Things,[12] means that products are including complex software or new materials that interact with both users as well as other smart devices. This allows them to connect and control other devices, creating opportunities for integrated solutions and platforms. The inclusion of sensors can generate data that can be relayed but to the consumer for analysis and better decision-making or aggregated by businesses to inform product refinement and development.[13]

Insight 3: Consumer demand is changing the nature of products and services as those involved in making are incentivised to create 'unlocked' outputs that consumers can repair, continue to adapt and refine to generate a stream of ongoing value that can grow. This contrasts to objects previously being 'locked' with value constrained to the original design/desire of producers.

On the supply-side, the Internet of Things is transforming the potential of products. They are now able to provide data that can feed into the next iteration of product development, improvement and even maintenance. Additionally, digitally enabled products are becoming platforms around which further value can be created, such as an app that is created for use on a smart phone.

Economies of production

Making processes have always been subject to changes caused by technological progress. The most recent of these to cause significant disruption is the emergence of exponential technologies which is rewriting the rules of production. Research has shown that Moore's law – which states that the capacity of microchips, bandwidth and computers doubles every 18 months, representing exponential growth – also applies to other technological developments.[14] These other technologies include 3D printing, sensor technology, artificial intelligence, robotics, drones and nanotechnology, amongst others.

Although many of these technologies are not new (invented over a decade ago in some instances), recent reductions in cost, coupled with miniaturisation and a boost in computing power, makes them accessible for industrial use, often at relatively small scale. These cost reductions have facilitated the empowerment of individuals and small businesses to apply these technologies to problem solve and create innovate new products and services, decentralising the production process. For larger, more established businesses, they have allowed certain manufacturing processes to be streamlined, producing components which no longer require assemble of multiple individual parts, and also to rapidly prototype and test new products. The use of these technologies is a fundamental characteristic of Industry 4.0: they allow for products to be customised, for production to be flexible, and for cost savings to be achieved and sustained.

[12] Ibid.

[13] Ibid.

[14] Deloitte (2014), Industry 4.0 – *Challenges and solutions for the digital transformation and use of exponential technologies.* ***https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/manufacturing/ch-en-manufacturing-industry-4-0-24102014.pdf***

An example of the future potential of 3D printing is highlighted by WinSun, a Chinese business that is able to print housing units faster and more cheaply than can be achieved using traditional construction processes.[15] The business is seeking to expand globally with ambitions to open factories in 20 countries over the next few years, and has already signed a contract with the Egyptian government for 20,000 single story units. It is likely further uses will be identified as advances in the technology make them commercially viable.

Figure 2-6 Case study on Knyttan: The application of an end-to-end digital production technology in the fashion industry

The traditional production process for knitwear is lengthy, segmented, and has high barriers to entry. In most cases, a fashion designer who wishes to manufacture a new design will need to contract a factory to produce a set number of items, often months in advance. The garments are produced using industrial knitting machines, which must be coded to the exact specifications of the garment design it is manufacturing. This coding process takes a minimum of two days and is costly, therefore requiring designers to order high volumes of clothing to make the production of their designs financially viable.

Revolutionising this process, Knyttan has developed a piece of software that directly links the fashion designers digital clothing designs and specifications to the industrial knitting machines, eliminating the need for extensive code to be written for each individual garment. Furthermore, the business has developed an online platform that allows clothing designs to be viewed, altered, and ordered by customers directly. The moment a piece of clothing is purchased by the customer, the industrial knitting machines owned by Knyttan immediately begin to manufacture the garment. Not only is it now financially viable to produce knitwear without requiring high order volumes, but Knyttan's machines can immediately switch between printing different garment designs without the two-day coding lag-time. There are a number of ways in which Knyttan's operations reflect the activities and attitudes encompassed in making today.

Role of the customer: Knyttan places the customer at the centre of their operations – from having a hand in designing their individualised garment online, to then purchasing the item, which signals to the industrial knitting machine to begin production.

Collaboration: Knyttan has in-house fashion designers that design garments specifically for their business. The business also collaborates with external fashion designers that can offer their designs on Knyttan's website, offering their products directly to consumers without having to incur traditional manufacturing costs up-front. This creates huge opportunities for designers who otherwise would be unlikely to offer their designs to consumers due to: 1) need to manufacturing high quantities to be cost effective, 2) high barriers to access factories of production, and 3) high risk associated with paying to manufacture garments before sales are recorded.

Digital integration: Knyttan's software that now links garment design technology to the industrial knitting machines has resulted in a streamline production process that no longer relies on a multi-step production processes that uses both digital design technology and human interface with machines. Additionally, this product illustrates how digital production processes, characteristic of 'making' can be applied to sectors whose output is still very physical in nature.

Reduction in waste: The traditional process of knitwear manufacturing essentially requires the designer to place a bet on the number of garments they will sell several months down the line. As a result, there is high wastage in the industry, with around 10% of all clothes that are manufactured never being sold. Knyttan eliminates this wastage, as products are manufactured only once an ordered is placed.

Source: Deloitte analysis and stakeholder discussions

[15] Guardian (26th Feb 2015), *3D Printed Cities: Is this the future? Accessed 28 May 2015:* ***http://www.theguardian.com/cities/2015/feb/26/3d-printed-cities-future-housing-architecture***

Another factor changing the economies of production is the reduction in the barriers to learning, entry and commercialisation. Barriers to learning are being eroded due to a host of resources (both online and in person) that are enabling the tacit transfer of knowledge – knowledge gained by doing – to become easier, faster and more accessible.[16] These include tools such as Massive Open Online Courses (MOOCs) and online forums where users come together to share ideas and solve problems. Similarly, tooling technology and access to it has been democratised, with many making tools available on a sharing basis, at no cost or on a freemium basis. This allows individuals and small businesses to make without investing large up-front sums of capital. Tools and equipment are becoming increasingly more accessible for individuals thanks to the establishment of numerous makerspaces, where makers are able to realise the wide range of benefits that come from sharing space, tools and experiences with one another.

Figure 2-7 Case study on Sugru: Empowering customers to realised their own end-use for the product

- Sugru is a product that enables individuals to reimagine, repurpose and "fix" existing items. It is mouldable glue that hardens into flexible rubber and can withstand a wide range of temperatures and environments.
- Launched to the public five years ago, the unique product was named one of Time magazine's top 50 inventions of 2010 and has received many accolades since.
- Starting small: During the product development phase, the team behind Sugru explored industrial uses for the material, including improving the grip of stationery products and garden tools. Ultimately, it was decided that progress in partnership with larger companies was too slow and the company decided instead to "start small and make it good". The brand has grown with the help of a loyal and passionate community of over 1 million users around the world who have shared their own applications via social media.
- Fast-fail and learn by doing: Through the company's life, there have been a number of challenges to which it has had to respond including the rapid growth to support launching into retail and responding the ever growing demands of customer demand. New colours have been developed and the shelf life of the product increased.
- Non-traditional funding: Sugru's route to commercialisation includes a number of non-traditional funding sources. It received a Nesta Creative Pioneer grant of £35,000 in 2005 which was used to get the project off of the ground following a number of private investments. Most recently a successful campaign has helped raise £1m of investment through the crowdfunding website Crowdcube.
- Involving the customer in the production process: The final stage in the production process of Sugru is performed by the consumer, who determines its end use from a wide range of possibilities. Sugru empowers the customer to create and make personalised items, as well as devise new and unique uses for the technology. Example uses include repairs to household appliances and reinforcing cables right through to more extensive modifications such as childproofing and soundproofing furniture – many of which might not have been realised without allowing consumers to take control of the final stage of design and production.

Source: Deloitte analysis and Sugru website

The route to commercialisation has also become more accessible, largely due to applications of new technology that has given creators direct access to finance, talent, production lines and talent, e.g. crowdsourcing finance and talent.

Insight 4: Exponential technologies, coupled with online learning platforms and new forms of finance have empowered individuals and start-ups to enter markets they previously would not be able to compete in due to lack of knowledge, capital and scale.

For large manufacturing businesses these technologies have enabled them to streamline production, whether through using a technology such as additive manufacturing in house, or by now being able to

[16] Ibid.

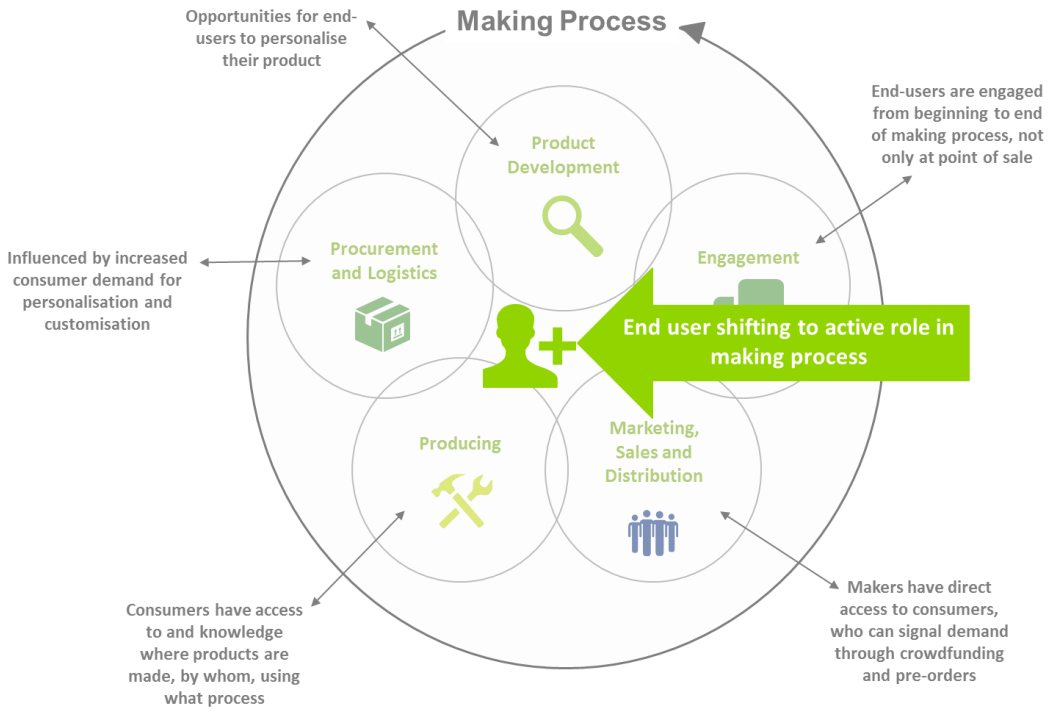
outsource production of highly specialised components to niche suppliers who use the technology. They can also rapidly prototype to experiment with new ideas.

Economies of distribution

A major change to the traditional linear making process is that the distance between producers and consumers is narrowing. This change is driven in part by the increasingly involved role consumers are playing in the design/ production process, as well as faster product life-cycles.[17] Consumers and producers are increasingly interacting with one another online, moving B2B businesses much closer to B2C businesses.

The traditional manufacturing model of 'build to stock' is rapidly being displaced by 'build to order'. Build to order, which has existed for some time, is now increasingly being seen as the model of choice for making, facilitated by direct consumer engagement and online platforms. This model is based on pre-orders and online promotion which serves the same purpose of traditional demand forecasting. As a result, businesses can produce precise quantities based on known order volumes, eliminating both the need for warehousing and also waste of unsold products.

Figure 2-8 Changes to producer and consumer interaction



Source: Deloitte analysis

The narrowing gap between producers and consumers is therefore leading to direct consumer engagement along various parts of the value chain. This narrowing of the gap between producers and consumers will challenge the value proposition for intermediaries. Using intermediaries to deliver stock to customers no longer becomes practical and reduces the reaction time of producers.

This shift is creating a customer affinity not just with the product itself, but with the business, brand and production process.[18] Crowdfunding is a very visible way this direct consumer engagement is evident, with businesses using these platforms to not only raise capital but also develop a community of loyal and engaged customers.

Insight 5: The changing economies of distribution are impacting both the role of the intermediary as well as the role producers and consumers. As the need for intermediaries such as warehouses and physical retail locations declines, consumers are now playing a much more active role in the economies of production.

No longer are businesses producing based on an estimated demand forecast, but technologies such as 3D printing makes it viable for them to produce in response to exact customer order numbers. This is

[17] Ibid.

[18] Ibid.

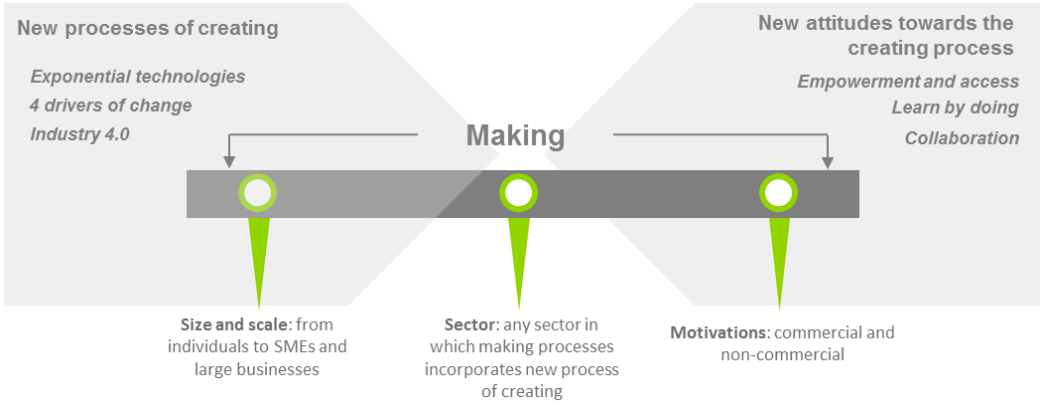
having an impact on the business models for other organisations in the value chain and can also reduce their carbon footprint and other waste.

2.4 Taking advantages of these shifts

It is evident from the changes discussed above, there are shifts occurring to both making processes and making attitudes and behaviours. This research has identified a large number of businesses and individuals taking advantages of these changes to develop innovative new products and services and change the way making is done in the UK. While on the surface those involved in making may look very different in terms of scale of operations, sector of the economy, academic background and final output, they often share the characteristics of:

- Collaboration: those taking advantage of changes in making regularly collaborate and cooperate with others involved in making inside their own industry (either as 'frenemies' or as partners) and with other industries and disciplines – this often manifests itself in designs being available on an open-source basis and costs being shared;
- A focus on design-led making: those taking advantage of changes in making place an emphasis on bringing a set of principles and methods to projects rather that set of formulae that place the user at the heart of the product/service;
- A willingness to rapidly prototype, try new things and not be afraid to fail; and
- An ongoing curiosity by those taking advantage of changes in making, and a desire to improve outputs and make them more relevant to customers.

Figure 2-9 Defining making



Source: Deloitte analysis

It is these individuals and businesses who share an ability to take advantage of these fundamental shifts and hold many of these common attitudes who are the focus of this piece of research. As illustrated below, this research focuses on those involved in making who are able to take advantage of the four fundamental changes and also exhibit the above attitudes and behaviours. The left circle of the diagram includes all individuals and businesses that are making commercial products or services in a way that responds to the four drivers of changes noted above. The right circle represents all people who are embracing the new attitudes and behaviour associated with empowerment of the individual/business to create, learn and share, either on a commercial or non-commercial basis. Making is thus defined as the people or businesses who are operating in these two spheres – they are adopting new making processes such as exponential technologies and doing so on the basis of collaboration and learn by doing.

This in turn disrupts the classic process of making to create something that is much less linear and something that does not have distinct elements.

Figure 2-10 New process of making

Source: Deloitte analysis

Figure 2-7 An updated definition of making for the purposes of this research

The next generation of making refers to those involved in making who are able to take advantage of the four shifts in demand, nature of products, economies of production and economics of distribution, and share common attitudes around collaboration and experimentation, can be found in multinationals and niche suppliers across all sectors developing new products and services that better meet customers' needs and addressing 'wicked' problems.

Source: Deloitte

Insight 6: It is the businesses and individuals involved in making that are able to take advantage of changes in processes and adopt new attitudes who are well placed to develop innovative new products and services that can disrupt business as usual.

3 Making in the UK

Key insights

7 Standard statistics fail to capture the extent and nature of making (as defined previously) in the UK today. Presently, the only way to measure the extent of making is through proxy measures.

8 Using R&D investment spend as a proxy for investment in making, the statistics show that a greater proportion of high-tech and engineering businesses are investing in training to be applied to innovation activities compared to all other sectors of the economy. This could be taken as proxy measure for businesses investing in processes to improve making.

9 Of businesses that are investing in new machinery and equipment, the largest proportion are acquiring computer software and computer hardware: potentially reflecting a willingness to adopt new technologies for making.

10 Using collaboration agreements as a proxy for new attitudes towards joint-working and sharing, it can be seen that businesses in high tech manufacturing and engineering are more likely to collaborate with and source information from customers or end-users compared to other sectors in the economy – these are characteristics of those involved in making as defined.

11 The aerospace, healthcare, creative industries, energy and motor sport sectors are most active in using additive manufacturing technology in the UK today, a proxy for new making processes.

12 The rise in maker spaces is also evidence of the growing scale of making in the UK (as previously defined). These spaces provide a space for those involved in making to collaborate, share ideas and stimulate new thinking. Economic theory suggests that these agglomerations can play a significant role in generating jobs and driving economic growth.

13 There are a number of dedicated initiatives to support making in the UK currently. As a rough proxy for the size of private financing for making, it can be seen that crowdfunding has increased (both in total volume and number of businesses receiving funding).

14 The skills required by making businesses draw more heavily from the technical and digital areas. This is now well recognised with number of initiatives in place to provide young people and adults with the skills to take advantage of new making processes.

This Chapter seeks to identify making in the UK today, based on the definition posited in the previous Chapter. It sets out some of the challenges in doing so and presents some proxy indicators and analysis of the wider making eco-system to provide an indication of the scale of making activities in the UK today.

3.1 The challenge of measuring the new ways of making

As the previous Chapter highlighted, making occurs across the entirety of the economy. There is no single sector that can be labelled as 'making' and no single set of products and services associated with making (though making is often collapsed into manufacturing). This poses a number of challenges to measuring and identifying making activity in the UK economy today.

In particular, there are several reasons for this:

- Making is a process not a product – meaning it can occur in many sectors of the economy, however economic activity in national statistics is measured by sector specific output, not the way in which it is produced. The operation of MakieLab is a good example – there is no way to distinguish between a toy manufacturer like MakieLab that is using advanced 3D printing techniques and toy maker using traditional manufacturing or even hand-made methods.
- Making products and services are not sector specific- the integration of the digital and physical interface common to the 'making' process means that they are unlikely to fit into one specific standard industry classification code used by Government to measure economic activity. The business Knyttan is a prime example – the product they have created is a piece of software, which connects digital fashion design programmes directly to industrial knitting machines. Nevertheless, the final output of their product is a piece of clothing. Allocating this business's activity to a single sector does not accurately reflect its operations.
- Making activities are not size specific – large corporates can be involved in 'making' as can SMEs and the self-employed. Just as all businesses within one sector cannot be assumed to be 'making', nor can all people in one size segment of the economy. Furthermore, large businesses may have certain internal teams that are making by collaborating in R&D with SMEs, however this may not be reflective of the business in its entirety.
- Open-source and sharing – these attitudes and processes common to 'making' cannot be measured through traditional R&D and innovation indicators such as patents and formal co-operation agreements. In the case of Knyttan, their business model is fundamentally based on collaboration with clothing designers who use Knyttan's online platform to bring their designs to market. Similarly, large manufacturers are using technologies such as Team Centre which shares R&D information with external suppliers. These forms of collaborations are becoming fundamental to the businesses are not just occurring during the R&D process.

Given the limitations of current available data, it is nearly impossible to directly measure making activity using standard published statistics. Nevertheless, the two elements that represent making as defined in the previous chapter – new processes of creating and attitudes towards making – can be analysed in isolation and used as a proxy for making activities overall. Specifically, the extent to which learning and collaboration is occurring in the economy can be used as a proxy for the 'attitudes' component of making can be measured. The take up of the exponential technologies such as additive manufacturing as can be regarded as a proxy for the new making process. Finally, the wider socio, economic and political eco-system in which UK making activities occur has evolved in recent years can be observed to give an indication of the size and extent of making.

Insight 7: Standard statistics fail to capture the extent and nature of making (as defined previously) in the UK today. Presently, the only way to measure the extent of making is through proxy measures.

3.2 Evidence of making activities

Learning

As confirmed by research by NESTA, a fundamental component of making activities is learning. Through stakeholder discussions, it was found that it is common for makers to learn to use new technologies and processes, whether that be via online platforms, other digital makers, or other sources. As such, an understanding of the extent to which people (and businesses) are learning about new tools and technologies may provide an indication of where, and the extent to which, making is occurring.

The UK Innovation Survey (UKIS) 2011 and 2013 collects data on the proportion of businesses that acquire external knowledge or invest in internal training with the purpose of applying it to innovative/creating/making activities. Innovation is an important qualifying proxy indicator of making, because it represents businesses who are striving to create something new of economic value. The most recent UKIS survey found that overall, a greater proportion of high-tech and engineering-based manufacturing businesses acquired external knowledge or invested in training compared to other businesses. Specifically:

- 20% of high-tech manufacturing businesses and 19% of engineering-based manufacturing businesses invested in training for innovative activities, compared to 14% across all sectors

- Investment in training was more common amongst larger businesses, however the proportion of businesses with 10-49 employees that invested in training increased by 3 percentage points between 2011 and 2013 compared to a 1 point decrease amongst businesses with 250+ employees.

Insight 8: A greater proportion of high-tech and engineering businesses are investing in training to be applied to innovation activities compared to all other sectors of the economy. This could be taken as proxy measure for businesses investing in processes to improve making.

While a greater proportion of larger businesses are investing in training, this is also on the rise with small and medium sized businesses.

UKIS also publishes data on the proportion of a business's total expenditure that is spent on acquiring new technology for innovative purposes. New technology is an interesting proxy indicator because it illustrates businesses that are both engaging with technologies (which could be disruptive) to create, and as a by-product also need to learn how to use such technology.

The survey found that of the businesses surveyed, the largest proportion of investment in machinery and equipment was in computer software (acquired by 23% of businesses), followed by computer hardware (acquired by 20% of businesses). Other notable findings that may evidence making activities are:

- While a greater proportion of larger businesses acquired new machinery and hardware, businesses with 10-49 and 50-99 employees saw the greatest point increase in acquisition of computer hardware and software over 2011-2013. This may be a reflection of decreasing price of such technologies
- The proportion of high tech manufacturing businesses that acquired computer software (30%) is above the survey average (23%), however this proportion increased only slightly over 2011-2013. This could be a sign of businesses which are early adapters and thus already possess the technology others are acquiring.
- Across the broad sectors, engineering-based manufacturing is that which has the largest proportion of businesses acquiring computer software (32%), a clear indication of the digitisation of the sector activities. This sector also has the largest proportion of businesses who have acquired computer hardware (26%).
- Interestingly, the construction sector is that which had the greatest point increase in the proportion of businesses that acquired computer software (7 point increase), potentially reflecting the growth of advanced building technologies.

Figure 3-1 Businesses that have acquired new machinery, equipment or software, % of total businesses surveyed

	2013			Point Change 2011-13		
	Advanced machinery	Computer hardware	Computer software	Advanced machinery	Computer hardware	Computer software
% of all businesses	8.6	19.9	23.3	0.3	3.7	4.0
By Size of Business (no. employees)						
10-49	7.9	19.4	22.5	0.4	3.7	4.0
50-99	11.1	23.0	26.7	0.6	5.3	5.1
100-249	12.2	21.3	26.9	-0.5	2.5	2.9
250+	13.5	20.4	26.3	-0.2	1.3	2.4
High/low Tech Industries						
High tech manufacturing	16.6	23.7	30.4	1.0	0.5	0.9
Low tech manufacturing	21.8	21.4	23.4	-0.9	2.3	0.6
Other industries	6.2	19.4	22.7	0.7	4.2	4.7
Broad Sectors						
Primary Sector	19.1	11.6	17.4	-5.1	-8.1	-5.8
Engineering-based manufacturing	21.2	26.1	32.2	-2.4	-1.1	-2.8
Other manufacturing	20.9	21.0	23.5	0.0	3.2	2.2
Construction	6.4	17.7	21.6	2.1	5.7	7.1
Retail & distribution	6.4	20.5	23.2	-0.1	3.4	3.5
Knowledge intensive services	6.3	24.0	29.1	-0.3	2.1	2.4
Other services	20.9	21.0	23.5	0.0	3.2	2.2

Source: UK Innovation Survey 2011 and 2013, Deloitte Analysis

Insight 9: Of businesses that are investing in new machinery and equipment, the largest proportion of businesses in the economy are acquiring computer software and computer hardware. Over the period 2011 – 2013, small and medium businesses saw the greatest increase in acquisition of computer hardware and software; potentially this is a reflection of the decreasing price of such technologies and a willingness to adopt new technologies for making.

The construction sector is the sector which had the greatest point increase in the proportion of businesses that acquired computer software over 2011-13, potentially reflecting the growth of advanced building technologies for making.

Collaboration

Collaboration is another fundamental component of the making process – as highlighted earlier, people involved in making are likely to collaborate with other makers and end-users.

The UKIS collects data on the proportion of innovating businesses that have cooperation agreements with external actors, including consumers. They also track where businesses source external information to feed into their innovation activities. The interactions that makers have with customers and end users is a direct reflection of the disruptions occurring in the traditional manufacturing process, and this is highlighted in the UKIS data:

- While 66% of all innovation active businesses have cooperation agreements with customers, this figure rises to 73% for high tech manufacturing and 79% for engineering based manufacturing businesses.
- A greater proportion of high tech manufacturing and engineering based manufacturing businesses also source information from their customers (33% and 35%) compared to all businesses (24%).

The full survey results are show below.

Figure 3-2 Cooperation with and information sourcing from external sources, proportion of businesses, 2013

	Cooperation Agreements			Source of external information		
	Customers or end users	Competitors	Consultants, commercial labs	Customers or end users	Competitors	Consultants, commercial labs
% of all businesses	65.6	29.2	27.1	24.1	10.7	10.9
High/low Tech Industries						
High tech manufacturing	72.6	25.5	30.4	32.6	13.5	10.6
Low tech manufacturing	70.5	22.7	32.6	26.4	8	10.9
Other industries	63.5	31.2	25.4	22.8	10.9	11
Broad Sectors						
Primary Sector	53.9	21.5	29.1	26.6	2.3	4.5
Engineering-based manufacturing	78.7	23.4	32.5	35.4	11.2	9.5
Other manufacturing	68.3	22.6	31.7	26.6	8.6	10.5
Construction	69.0	30.0	20.7	16.1	10.3	7.5
Retail & distribution	57.4	29.5	27.7	19.6	7.5	11.5
Knowledge intensive services	70.1	31.9	28.0	35.7	15.9	14.5
Other services	63.5	32.9	23.5	22.2	12.1	10.8

Source: UK Innovation Survey 2011 and 2013, Deloitte Analysis

Figure 3-3 Case study on GE

FirstBuild is a GE subsidiary and the test case for the business's new manufacturing model – a combined online and physical co-creation community for makers, designers and engineers. It is a system that combines the capabilities of the large manufacturer and a lean start-up. GE established FirstBuild after realizing that to build products more quickly, it needed to test more ideas with more people more frequently. It can produce small quantities and discontinue products if unsuccessful, or draw on GE's supply chain to manufacture at high volumes products are successful and generate high demand.

It is an example of how large manufacturing businesses are collaborating with nimble makers to develop products in a 'fast-fail' mentality, drawing on the resources of a business such as GE to scale-up ideas if deemed successful after being tested in the market. FirstBuild uses crowdfunding platforms as a way to test their

products, allow them to produce a small amount based on actual orders as opposed to forecasted demand traditionally used in the production process. The way in which GE has integrated making activities into their operations and is collaborating with individual makers has created more value for the business. It allows them to cut development time and cost while insuring against large-scale launches of unsuccessful products.

Source: Deloitte Center for the Edge (2015), *The future of manufacturing: Making things in a changing world*

Collaboration can also be witnessed in an ad-hoc way through the increasingly common decision for businesses (especially large corporates) to locate their R&D operations at external locations, often in digital/ tech clusters. This shift illustrates two important points related to the digital making movement. Firstly, that making activities tend to cluster in physical locations due to the spill over benefits they gain from agglomeration. Secondly, urban locations and digital clusters (such as tech city) offer closer access to collaboration partners as well as end-users and customers.

Related to instances of more collaboration, the Government Office for Science recently identified the trend of onshoring[19] production back to the UK due in part to the advantages of co-locating R&D and production.[20] For example, in July 2013, a major UK high street retailer set a 2 year 15% growth target for sales of goods made in the UK and in the same year an online bathroom furniture retailer decided to relocate 50% of contracts held with Chinese manufacturers back to the UK, citing much faster turnaround times from design to production (from 4 to 6 months to 6 weeks). It notes that while this reflects a recognised need to be closer to market, it also illustrates the changing way in which manufacturing businesses are trying to compete in a global market. Many UK manufacturing businesses are now competing not by providing 'more for less', but on quality, speed of delivery and customisation.

Insight 10: Businesses in high tech manufacturing and engineering are more likely to collaborate with and source information from customers or end-users compared to other sectors in the economy – these are characteristics of those involved in making as defined.

The Government Office for Science recently identified the trend of onshoring production back to the UK, due in part to the advantages of co-locating R&D and production.

Exponential technologies

Exponential technologies – a fundamental component of new production methods and Industry 4.0 – include additive manufacturing, robotics, sensor technology, drones and nanotechnology, amongst others. Although the application of these technologies is characteristic of the making process, it is difficult to accurately measure the extent to which they are being applied in a given sector of the economy. Nevertheless, additive manufacturing (often referred to as 3D printing) is one of the most publicised exponential technology and as a result, its take-up can be measured and used as a proxy for making as defined.

Additive manufacturing (AM) involves constructing a product from sequential layers of fine powder or liquid. The materials used for printing can range from metals to plastics and composite materials. It has already started to be applied to manufacturing in a number of sectors in the UK today. The Royal Academy of Engineering suggest that the fastest-growing areas for AM are medical and dental, automotive, and aerospace and this is expected to continue into the future.[21] Innovate UK sees a similar pattern, indicating that aerospace, healthcare, creative industries, energy and motor sport sectors are most active in using AM technology in the UK today.[22] The drivers of additive manufacturing adoption across these industries is different, and range from increased design freedom

[19] Defined as relocating production back to the UK to be closer to consumers and designers.

[20] Government Office for Science (2013), *The Future of Manufacturing: A new era of opportunity and challenge for the UK.* ***http://www.ifm.eng.cam.ac.uk/uploads/Resources/Future_of_Manufacturing_Report.pdf***

[21] Royal Academy of Engineering (2013), *Additive manufacturing: opportunities and constraints:* ***http://www.raeng.org.uk/publications/reports/additive-manufacturing***

[22] Innovate UK (2012), *Shaping our National Competency in Additive Manufacturing:* ***https://connect.innovateuk.org/documents/2998699/3675986/UK+Review+of+Additive+Manufacturing+-+AM+SIG+Report+-+September+2012.pdf/a1e2e6cc-37b9-403c-bc2f-bf68d8a8e9bf***

(which is the stated reason for the aerospace and automotive adopting it) to customisation (which is attractive to healthcare and creative industries).

The Royal Academy of Engineering assessed the current and future market opportunities for additive manufacturing. It noted that the global market for additive manufacturing products and services in 2012 grew to over $2 billion (a 29% compound annual growth). A total of nearly 8,000 professional-grade industrial systems were sold in the same year, compared to 6,500 the year previous. Projections indicate that the value of this industry will reach $4 billion in 2015 and $10.8 billion by 2021.[23] In terms of the application of AM technology, the Academy notes that there has been an increase in the direct part production, as opposed to prototyping commonly associated with the technology.

Insight 11: The aerospace, healthcare, creative industries, energy and motor sport sectors are most active in using additive manufacturing technology in the UK today, a proxy for new making processes.

3.3 The wider making eco-system

There are a number of ways in which 'making' activities are linked to and supported by the wider making eco-system. These include physical places for 'making', funding and investment and Government support. The extent of the making ecosystem can be regarded as a strong proxy for the health of the sector.

Physical spaces and events

One indication of making in the UK is the rise of 'makerspaces' which provide a forum for collaboration and sharing and showcasing ideas. Nesta has developed an open dataset[24] of such spaces in the UK, which as of April this year had identified 97 Makerspaces in the UK.[25] This spaces, as well as providing a location to make, also facilitate sharing of tools to make: digital fabrication tools were the most commonly reported (present in 73% of makerspaces) and were more common than even general hand tools (present in 60% of makerspaces), suggesting that making activities using new digital making technologies are becoming more and more commonplace. Nearly two thirds of Makerspaces reported that they collaborated with others, a high number taking into account that the majority or towns and cities were found to have only one Makerspace.

These spaces offer more than an environment to make: the top three reported reasons for using Makerspaces (in order of popularity) were "socialising", "learning" and "making", suggesting further links between making activities and community engagement. These spaces are also largely open to new members, with over half (56%) of Makerspaces open to the public at set hours.[26]

The research also showed that:

- 42% of makerspaces are staffed by volunteers with an equal proportion staffed by full or part time technicians; and
- 80% of makerspaces in the UK have a user base that is at least 50% male.

Figure 3-4 Case study on Here East

Here East

Here East comprises 1.2 million square feet of commercial space set in the Queen Elizabeth Olympic Park. Based in the former Olympic Press and Broadcast Centre, it is being developed by iCITY, the business selected by the London Legacy Development Corporation to deliver a legacy from the former Press and Broadcast Centres.

Here East is being developed with the purpose of becoming a hub and champion of making activities in the UK by bringing together cutting-edge infrastructure, flexible workspaces and an ecosystem of businesses focussed

[23] Royal Academy of Engineering (2013), *Additive manufacturing: opportunities and constraints:* ***http://www.raeng.org.uk/publications/reports/additive-manufacturing***

[24] Information on the dataset is available at ***http://www.nesta.org.uk/blog/open-dataset-uk-makerspaces***

[25] Nesta website (Open dataset of UK Makerspaces), accessed 7th May ***http://www.nesta.org.uk/publications/open-dataset-uk-makerspaces-users-guide***

[26] Nesta (2015), *Open dataset of UK Makerspaces; a user's guide* (all statistics in the paragraph are taken from this analysis)

on making. It is inspired by the inventiveness, curiosity and energy of the making movement. It includes shared workspaces and public areas to foster a tight community, alongside a shared yard with space for discussion and events, a landscaped canal side and artisanal cafes, shops and restaurants.

Here East will provide flexible co-working spaces and managed incubation services including access to mentoring, skills and facilities to support making. The Press Centre, the largest building at Here East comprising 647,410 square feet, will house the workspaces as well as retail units, large-scale studios, start-up and grow-on space for businesses.

Source: Deloitte Analysis

Makerversity in Somerset House, London is another example of a physical space that has been opened to support making activities. Makerversity comprises 3,000 square metres of space with access to tools and a workshop for member businesses. Specifically, Makerversity has a manual workshop and a digital workshop, an assembly space, a photo studio and sound studio. Both the tools and technologies provided as well as the collaborative environment which Makerversity supports is directly linked to making activities, particularly start-up makers.

Universities are also supporting Makerspaces for both teaching and research purposes. For example, University College London supports an Institute of Making, a cross disciplinary research club with access to materials and equipment.[27] Other examples of ongoing research include Cambridge University which has been awarded funding specifically for the purpose of researching the potential of digital fabrication for the UK economy (which is described as a revolution)[28] and the Royal College of Art which is currently hosting a two year research project into the role of Makerspaces in redistributed manufacturing.[29]

Figure 3-5 Case study on Maker Faire

Perhaps one of the most cited events centred on making is Maker Faire. This event was created by Make magazine, which encourages and celebrates arts, science, crafts and engineering. It brings together both hobbyists and commercial Makers, both of which can take stalls to exhibit ideas and products, or simply visit to explore other stalls. Maker Faire has become a global event, with events organised throughout America, in Tokyo, Shenzhen, Oslo and Rome as well as the UK. The UK hosted its first Faire in Newcastle in 2009 as part of the city's 10 day ScienceFest, and has hosted events in other cities.

The concept of open events that bring people engaged in making is now extending into high-tech and high-value making activities. For example, in August 2015 University College London is hosting a festival around engineering, science and technology. The University is inviting its staff and students to propose activities such as interactive stands, demos and workshops that could take place at the festival. With the purpose of creating enthusiasm and engagement around engineering and technology activities illustrates the depth and breadth of making today.

Source: Deloitte analysis

Insight 12: The rise in maker spaces is evidence of the growing scale of making in the UK. These spaces provide a space for those involved in making to collaborate, share ideas and stimulate new thinking.

Economic theory suggests that these agglomerations can play a significant role in generating jobs and driving economic growth.

Funding and investment

The funding and investment environment is particularly important for entrepreneurs and start-ups involved in making activities. In many ways, these businesses are no different than other start-up businesses that require initial investment to test product feasibility, achieve a proof of concept, and ultimately go to market. Nevertheless, there

[27] UCL website, accessed 7th May ***http://www.instituteofmaking.org.uk/makespace***

[28] University of Cambridge Department of Engineering website, accessed 7th May ***http://www.ifm.eng.cam.ac.uk/research/teg/digital-fabrication/***

[29] Future Makerspaces website, accessed 7th May ***http://futuremakespaces.rca.ac.uk/***

have been specific funds established by organisations such as Nesta and Nominet to specifically support the work of people involved in making.

The Digital Makers Fund is an example of successful private and public sector collaboration. Supported by government, Nesta, Nominet and Mozilla initially committed £225,000 to fund projects to equip young people with skills to become Digital Makers. In March 2013 and March 2014 cohorts of 7 organisations were granted funding to undertake Digital Making projects throughout the UK.[30] Similarly, the Make Things Do Stuff Programme, launched by Nesta in 2013, provides information on how those interested in Digital Making can access resources to further their learning. It is also accompanied by workshops and activities run in schools and was supported by a number of corporate partners.[31]

Innovate UK (formerly the Technology Strategy Board) has also committed investment to develop 3D printing projects. In 2013 the organisation committed £14.7 million to help businesses to develop new manufacturing solutions in 3D printing technology across industries including healthcare and energy.[32]

In addition to these making-specific sources of finance, there are other sources such as venture capital and crowdfunding available to start-ups. While it is not possible to distinguish between start-ups that access funding who are making (as defined previously) and those that are not, one can use the performance of different funding types as a proxy. Equity crowdfunding[33] is one form of finance which is still small in relative terms, but has grown significantly in recent years. Research undertaken by the British Business Bank found that crowdfunding is having a significant impact on seed-stage activity in the UK equity investment market, however an increasing number of crowd funded deals are occurring at the venture-stage.[34] In 2011, when this form of funding first became available in the UK £1.6m was raised across seven deals. However in the first half of 2014 alone, this figure had increased to £24m invested across 101 businesses. Nevertheless, these figures are still below other forms of finance such as peer-to-peer lending platforms.[35]

Insight 13: The ways in which makers need to be support are not dissimilar to other entrepreneurs and start-ups in the economy. There are a number of dedicated initiatives to support making in the UK currently.

As a rough proxy for the size of private financing for making, it can be seen that crowdfunding has increased (both in total volume and number of businesses receiving funding).

Public support for learning

In addition to the work of individual Makerspaces to promote making to the wider population, the UK government and a number of other agencies are working to promote making opportunities. A significant proportion of this work aims to provide opportunities for children and young people in order to impart digital literacy skills that will be vital when they undertake their future careers (e.g. adding coding to the National Curriculum), recognising the ability of making using transformative digital technologies to inspire interest in fields like computer programming and the digital creative industries.

In Northern Ireland, the Department for Culture, Arts and Leisure recently invested £350,000 into FabLab NI, an existing Makerspace.[36] Similar interest in Makerspaces has begun to be generated in the UK, where proposals by

[30] Nesta website, accessed 7th May ***http://www.nesta.org.uk/project/digital-makers***

[31] UK government website, accessed 7th May ***https://www.gov.uk/government/news/100000-young-people-to-become-digital-makers***

[32] BIS (2013), *£14.7 million boost for innovative 3D printing projects*: ***https://www.gov.uk/government/news/147-million-boost-for-innovative-3d-printing-projects***

[33] Equity crowdfunding is a form of investment that involves many individuals purchasing share capital online in a business

[34] British Business Bank (2014), *Equity Crowdfunding in the UK: Evidence from the Equity Tracker*: ***http://british-business-bank.co.uk/wp-content/uploads/2015/03/230315-Equity-crowdfunding-report-final.pdf***

[35] Nesta (2014), Understanding Alternative Finance: ***https://www.nesta.org.uk/sites/default/files/understanding-alternative-finance-2014.pdf***

[36] FabLab NI website, accessed 7th May ***http://www.fablabni.com/news/major-coup-fablab-derry-dcal-commits-additional-funding-fabricating-future-conference***

the Department for Business, Innovation and Skills were recently announced[37] to utilise disused military workshops to support veteran's start-up businesses. While relatively rare, there is evidence that interest in providing 3D printers at public libraries is increasing, with 3D printers having been available (sometimes only temporarily or on a demonstration basis) at Exeter, Dundee and Manchester libraries.[38]

As well as supporting Makerspaces, the UK Government, as well as non-profit and private agencies, are taking an active role in encouraging the principles of making amongst children and young people, realising the benefits of developing young peoples' digital literacy.

Insight 14: The skills required by making businesses draw more heavily from the technical and digital areas. This is now well recognised with number of initiatives in place to provide young people and adults with the skills to take advantage of new making processes.

[37] BIS website, accessed 7th May ***https://www.gov.uk/government/news/making-space-for-ex-military-personnel***

[38] Public Libraries News website, accessed 7th May ***http://www.publiclibrariesnews.com/practitioners/3d-printers-and-maker-spaces-in-libraries***

4 Impacts of Making in the UK Today

Key insights

15 It is estimated that today there are up to 22,200 direct jobs in London involved in making and up to 134,000 in the UK (including London). In addition, it is estimated that there may be an additional 5,700 to 7,600 supply chain jobs in London and between 121,700 and 164,000 in the UK as a result of direct making activities. Overall, the analysis estimates that between 255,500 and 298,000 jobs could be involved in making in the UK today.

At the UK level, making is more spread across a wide range of sectors. The largest proportion of active making jobs are estimated to be in construction (27% of UK making jobs) and architectural and engineering (14% of UK making jobs). Advanced manufacturing sectors such as machinery, motor vehicles and fabricated metal are also amongst the top 10 sectors in the UK.

At the London level however, there is a much higher concentration of making jobs amongst a fewer number of sectors. Creative industries have a greater proportion of making jobs at the London level, with motion picture, video and TV programme production (11%), advertising (6%) and publishing (5%) all within the top 10 sectors.

16 Currently making contributions between £15 and 18 billion to the UK economy annually. This includes the contribution from all types of makers – from SMEs to large multinationals.

17 Through its new processes and attitudes, making as defined can have a significant and positive impact on productivity in the UK, which in turn can drive economic growth and prosperity.

This Chapter contains the first attempt to measure the economic value of making activities in the UK today. The value is assessed in terms of full-time equivalent jobs and gross value added and accounts for direct making activity as well as the supply chain impacts it creates.

4.1 What making activities are being measured?

The modelling used to estimate the economic value of making today is based on the definition in Chapter 2. It uses the occupations of people employed assumed to be involved in making, and then looks at the sectors in which these people are employed to identify the types of activities they are undertaking. The detailed methodology underlying the modelling is provided in Appendix 1.

The empirical estimates are based on a number of key assumptions, shown below.

Figure 4-1 Model assumptions

Assumptions around making activities	Allowances in economic modelling	Limitations
Making is defined not by the output but by the skills and processes used to make	The model bases its estimate of making activities on the occupations of people in employment involved in making. Occupations included, on the basis of stakeholder discussions, are: research and development managers, chemists, bio scientists and biochemists, mechanical engineers, civil engineers, electrical engineers, electronics engineers, design and development engineers, engineering professionals and software professionals The model calculates the proportion of people employed in these occupations across all sectors of the economy using ONS statistics on occupations by sector.	Making activities often involve the application of technologies and processes in new ways. This implies that someone may be involved in making but not be employed in the making occupations as defined. This activity would not be captured in this analysis.
Making can occur in many sectors across the economy and is not limited to manufacturing	The modelling considers all sectors in which people with making occupations are employ. A sense checking process has been undertaken to remove those sectors which are unlikely to contain making activities.	Sectors which do not employ people in the making occupations, but are participating in making, will not be included.
Many people may have the skills and capabilities to make, however they may not be doing so in a way that is captured by industry statistics[39]	The model assumes that the proportion of employees with making occupations in a sector equals the maximum number of potential makers in a sector. However the model assumes that only a proportion (initially set at 10%) of these 'potential' makers are actually making.	Assuming 10% of potential makers are actively making is a conservative estimate and may not capture all making.

Source: Deloitte analysis

Given these assumptions/limitations, the numbers presented below should be treated as conservative and indicative. As data on making improves, one would expect more accurate estimates. The numbers below represent a first analysis that can be improved upon.

4.2 Jobs supported in the UK and London

Job numbers

Two types of jobs have been estimated: direct jobs and supply-chain jobs. Direct jobs refer to those jobs that are directly involved in making. Supply chain jobs refer to those jobs that are in businesses that supply inputs to making businesses, and are, in a sense, supported by direct jobs.

Deloitte estimates that today there are up to 22,200 direct jobs in London involved in making and up to 134,000 in the UK (including London). In addition, it is estimated that there may be an additional 5,700 to 7,600 supply chain jobs[40] in London and between 121,700 and 164,000 in the UK as a result of direct making activities. Overall, the analysis estimates that between 255,500 and 298,000 jobs could be involved in making in the UK today.

[39] This may be because they are in full-time employment and making in their spare time. Or because they are employed in a role that could participate in making but currently is not

[40] The analysis has considered the traditional supply chain impacts of the sectors in which making is present and also what the supply chain may look like if we assume making activities are much more digital in nature. In both scenarios, sectors such as education services, employment services and services to buildings

Figure 4-2 Total number of jobs involved in making today, London and UK

	Direct Jobs	Supply Chain Jobs	Total
London	22,200	5,700 - 7,700	27,900 - 29,900
UK	134,000	121,700 - 164,000	255,500 - 298,000

Source: Deloitte Analysis

The number of jobs involved in making activities in the UK today is a conservative estimate and it is likely that the actual figure is higher.

The spread of estimated direct jobs across different economic sectors is shown below.

Figure 4-3 Top 10 sectors by proportion of direct making jobs, London and UK

UK				London			
Sector	**No.**	**% of making jobs**	**% of total sector jobs**	**Sector**	**No.**	**% of making jobs**	**% of total sector jobs**
Construction	35,500	27%	3%	Human health services	4,500	20%	2%
Architectural and engineering services; technical testing and analysis services	18,100	14%	4%	Construction	3,300	15%	2%
Machinery and equipment	6,100	5%	3%	Architectural and engineering services	2,800	13%	3%
Manufacture of motor vehicles, trailers and semi-trailers	6,300	5%	4%	Motion picture, video and TV programme production, sound recording & music publishing	2,400	11%	3%
Computer programming, consultancy and related services	6,900	5%	1%	Other professional, scientific and technical services	2,400	11%	5%
Scientific research and development services	6,700	5%	5%	Computer programming, consultancy and related services	1,700	8%	1%
Other professional, scientific and technical services	6,900	5%	4%	Advertising and market research services	1,300	6%	1%
Human health services	4,700	4%	<1%	Publishing services	1,100	5%	2%
Fabricated metal products	5,400	4%	2%	Scientific research and development	900	4%	5%
Computer, electronic and optical products	4,700	4%	4%	Information services	400	2%	2%
Other	32,400	24%	<1%	Other	1,400	6%	<1%

Source: Deloitte Analysis

It is less clear which sectors are in involved in the making supply chain. This is due to the fact that making activities are using new processes, technologies, and materials which require different inputs than the classic way of making. For example, there is no way to distinguish between a business using additive manufacturing to work with

rank as some of the largest supply chain sectors. When the analysis adjusts for more digital making activity however, sectors such as legal services and computer programming represent larger shares of the supply chain impacts. Similarly, sectors supplying physical inputs such as metal products decline.

Given the broad spectrum of making activities, it is likely that the sectors represented in the making supply chain fall in the middle of these two scenarios: while making does incorporate a greater use of technologies which can reduce the amount of physical inputs, it may also be the nature of products sourced through the supply chain are changing (e.g. greater use of advanced materials).

advanced materials (e.g. powdered metals) versus a business producing using traditional welding together of individual metal components. These differences will have an impact on the supply chain.

Insight 15: It is estimated that today there are up to 22,200 direct jobs in London involved in making and up to 134,000 in the UK (including London). In addition, it is estimated that there may be an additional 5,700 to 7,600 supply chain jobs in London and between 121,700 and 164,000 in the UK as a result of direct making activities. Overall, the analysis estimates that between 255,500 and 298,000 jobs could be involved in making in the UK today.

The UK and London differ in terms of which sectors the largest proportion of makers are operating in. At the UK level, making is more spread across a wide range of sectors. The largest proportion of active making jobs are estimated to be in construction (27% of UK making jobs) and architectural and engineering (14% of UK making jobs). Advanced manufacturing sectors such as machinery, motor vehicles and fabricated metal are also amongst the top 10 sectors in the UK.

At the London level however, there is a much higher concentration of making jobs amongst a fewer number of sectors. Creative industries have a greater proportion of making jobs at the London level, with motion picture, video and TV programme production (11%), advertising (6%) and publishing (5%) all within the top 10 sectors.

Productivity

The productivity of direct making jobs is higher than the UK average, reflecting the high value sectors of the economy in which making activity is taking place. Based on the sectors in which making is thought to be taking place, the productivity per worker for London makers is £21,800 greater than the average across all employment in London. At the UK level, it is estimated that the productivity of making jobs is £24,300 above the UK average.

Figure 4-4 Productivity per worker (£), London and UK

	Direct Making Jobs	Making Supply Chain Jobs	Average across economy
London	£87,800	£65,000	£66,000
UK	£72,000	£51,800	£47,700

Source: Deloitte Analysis

4.3 GVA supported in the UK and London

Gross Value Add (GVA) measures the contribution to the economy of each individual producer, industry or sector in the United Kingdom. In national accounts GVA is output minus intermediate consumption; it is a balancing item of the national accounts' production account. Its relationship to GDP is as follows: GVA + taxes on products - subsidies on products = GDP. The analysis below calculates the size of the making's GVA contribution in the UK and in London.

Based on the estimated number of direct jobs participating in making activities today (as defined previously), the analysis estimates that direct making activities generate £1,400m GVA in London and £9,600m GVA in the UK as a whole annually. When the GVA supported through the supply chain is included, these figures rise to £1,800m for London and £18,100m in the UK annually.

Figure 4-5 Total GVA generated by making activities today (£millions), London and UK

	Direct GVA	Supply Chain GVA	Total
London	£1,400	£400 - £500	£1,800 - £1,900
UK	£9,600	£6,000 - £8,500	£15,600 - £18,100

Source: Deloitte Analysis

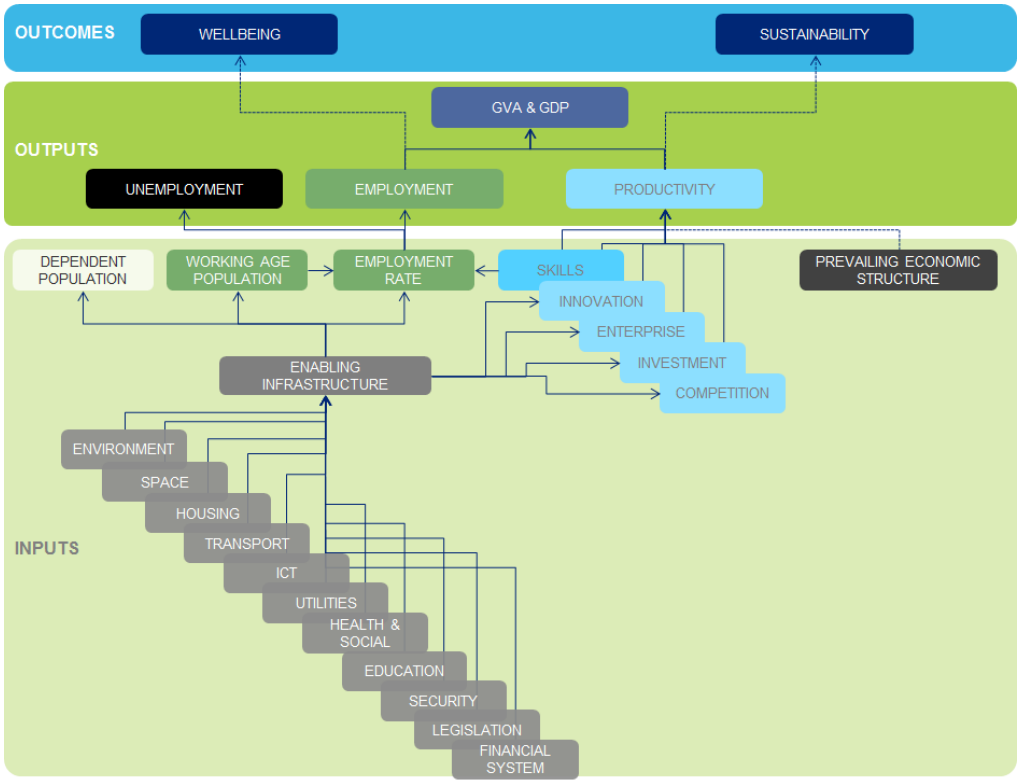
Insight 16: Currently making contributions between £15 and 18 billion to the UK economy annually. This includes the contribution from all types of makers – from SMEs to large multinationals.

4.4 Wider impacts

In addition to the current economic impacts that making activities have on the economy today, making activities also generate wider benefits to the UK economy and society that are not captured in the numbers of jobs supported or GVA generated.

A country's long-term prosperity, which is measured by GVA, jobs and happiness is ultimately determined by two groups of inputs: enabling infrastructure and productivity drivers – as shown below.

Figure 4-6 Long Term Economic Growth Framework



Source: Deloitte analysis

In the diagram above, it can be seen that beneficial outcomes to society are function of enabling infrastructure (such as housing, ICT, security and education) and drivers of productivity. With respect to productivity, in February 2015 the OECD reported that "weak labour productivity [in the UK] has been holding back real wages and well-being. The sustainability of economic expansion and further progress in living standards rest on boosting productivity growth."[41]

Making activities represent a significant opportunity to contribute to the rise in productivity the UK must achieve.

- Skills: making activities are already influencing formal education for young people as well as cultivating a culture of lifelong learning and experimentation.[42] Making activities are raising awareness about the importance of experiential learning or learning by doing, as well as the need for students to develop digital skills from a young age. Furthermore, products that are emerging from making activities are designed in a way that facilitates the user learning about its underlying technologies. Bare Conductive's electronic paint is a prime example, as the product itself requires user to manipulate and apply it in a personalised way. Creating a culture of learning and exploration can increase human capital, which in turn can drive productivity.
- Innovation: the process of creating something new of economic value, or innovation, is supported by making activities in multiple ways. Not only do the exponential technologies used allow for new production methods and products to be created, but they also allow existing technologies to be applied which couldn't before. For example, in aerospace engine manufacturing, additive manufacturing is supporting innovation around

[41] OECD (2015), Economic Surveys United Kingdom: ***www.keepeek.com/Digital-Asset-Management/oecd/economics/oecd-economic-surveys-united-kingdom-2015_eco_surveys-gbr-2015-en#page1***

[42] Deloitte (2013), Impact of the Maker Movement. ***http://oaklandmakers.org/wp-content/uploads/2014/06/Impact-of-the-Maker-Movement.pdf***

advanced materials such as powdered metals, which existed before but manufactures lacked the technology to fully exploit them. This can help lower costs and improve competitiveness – which will drive productivity.

- Investment: making activities of businesses, from SMEs to large businesses, are attracting investment and growing new types of finance which previously did not exist in the UK. As businesses and individuals use the latest technologies that can expand their capacity to create and can also increase scale, which in turn can lead to economies of scale and scope which raises productivity. Businesses like Sugru, which seek substantial investment through crowdfunding platforms like Crowdcube and Kickstarter, create opportunities in the UK economy that might not have materialised were only the traditional funding mechanisms like bank financing available.
- Competition: making activities are increasing competition in the economy due to the reduction in barriers to learning, commercialisation and finance. This can introduce new players to the market who can generate new competitive pressures on incumbents putting pressure on prices and creating new incentives to innovate and better meet customer needs. The democratisation of additive manufacturing, for example, will drastically change customers' expectations regarding acceptable delivery times and levels of product customisation, forcing traditional manufacturers to adapt in order to compete. This can also serve to increase productivity as businesses are forced to become more efficient.
- Enterprise: similar to making activities' impact on competition, the reduced barriers to entry combined with the empowerment of individuals through democratised technologies is allowing people to commercialise ideas which otherwise would unlikely be possible. For example, MakieLab can provide its customers with dolls that are customised to the extent that the retail price could have been prohibitively expensive without additive manufacturing technologies that make small-bath production more practical. A culture of not being afraid to fail and more risk taking can also lead to more innovation, which again drives productivity.

Insight 17: Through its new processes and attitudes, making as defined can have a significant and positive impact on productivity in the UK, which in turn can drive economic growth and prosperity.

5 Maximising the Making Opportunity

Key insights

18 The conditions for growth for making organisations are similar to other organisations. However, given that many making businesses are likely to be small scale currently, there may be a need to focus supporting interventions on initiatives to help them scale-up.

19 The impact of making activities has the potential to increase and can be supported to do so by addressing the specific barriers facing makers as well as supporting the business eco-system. The greater number of individuals and businesses that are able to participate in making activities in the economy will contribute to increasing the productivity and long-run sustainability of the UK.

The number of people who participate in making activities (as defined in this research) in the economy is increasing and the overall contribution of making to the economy is likely to grow. This section analyses the identified challenges to maximising the making opportunity and sets out some potential mitigations.

5.1 Supporting growth

The conditions for growth

Many challenges facing making businesses are similar to those facing all businesses in the economy, such as access to finance and access to talent. In this respect, the Department for Business Innovation and Skills' (BIS) enablers of business success are relevant – internal capacity and capability; external environment; and vision of the business owner – these apply to all sectors and business size.[43] Getting these right can create the conducive conditions for business and economic growth for makers.

Focusing specifically on smaller and medium sized organisations, one key challenge is 'scaling up'. While much work has been done to foster start-ups and support large organisations, those in the middle are often neglected. There is thus a risk that innovative new makers quickly plateau and are unable to scale. Deloitte's analysis of Scale-Up programmes[44] – a holistic package of support for businesses displaying high growth characteristics – identifies six themes where interventions can be targeted to support scaling up. It notes that these themes align with the necessary conditions for growth, but in isolation each theme is likely to be an insufficient condition to generate economic growth in high growth businesses. These themes are: talent, mentoring, market stimulation, access to finance, infrastructure and culture.

The Scale-Up work also highlights that local and regional interventions to support business growth act as a primary driver of impact. Research on making activities indicate that this is also an important factor to increasing making activities in the UK. As this analysis has shown, the sector composition of making activities in the UK differs compared to that of London on its own suggesting tailored regional interventions may be appropriate to support making.

Insight 18: The conditions for growth for making organisations are similar to other organisations.

However, given that many making businesses are likely to be small scale currently, there may be a need to focus supporting interventions on initiatives to help them scale-up.

[43] BIS (2013), *Key Enablers of Business Success & the Economic Rationale for Government Intervention.* ***https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/266304/bis-13-1320-smes-key-enablers-of-business-success.pdf***

[44] Deloitte (2014), *The Scale-up Challenge.* ***http://www2.deloitte.com/content/dam/Deloitte/uk/Documents/strategy/deloitte-uk-scale-up-challenge.pdf***

Constraints to growth identified

Apart from general business support, there are other ways in which making activities can be supported in the UK. This research has highlighted that there are many making sectors in the UK contributing to economic growth and prosperity and these have the potential to expand further. The benefits of making to the UK economy could be maximised by increasing the number of individuals and businesses who are able to shift their producing activities into the realm of making and adopt the attitudes discussed. For a large manufacturing business, this may mean adapting new exponential technologies and digitally integrating their production with other external organisations in the value chain, and collaborating more widely. For an individual this may mean actually commercialising and bringing to market a product they have created through a making process.

Consultation for this report identified several barriers that are preventing more businesses and individuals partaking in making activities or growing existing making activities. These range from the need for physical spaces conducive for making, to access to mentors and greater protection around cyber security and IP rights. Further detail is provided below.

Figure 5-1 Identified constraints and mitigations

Challenge faced	Relevance to Making	How to counteract
Suitable accommodation for making activities	For start-up making businesses particularly, the issue of suitable accommodation for both incubation and grow-on space was noted as a challenge by consultees. The making businesses interviewed as part of this research noted that most of the incubation centres cater to the software start-up businesses and are not able to accommodate making businesses that have machines and require workshops space. This is compounded by the fact that making activities are increasingly clustering in urban areas, with many buildings in central London, for example, unable accommodate machinery and those which can are often not affordable.	Makerspaces are an example of how this challenge can be addressed, by giving makers access to spaces with the tools and equipment they require. Nesta's research on UK Makerspaces[45] identifies certain challenges facing the establishment and sustainability of makerspaces, which relate to time, money and coordination require to maintain these spaces.
Access to making mentors	The making businesses interviewed noted that much of the eco-system of support around start-ups is focused on purely digital and software start-ups. Access to mentors that had experience in making was highlighted as an important source of support makers in London wished they had better access to.	Some making businesses interviewed accessed mentors through incubation centres in London, while others accessed mentors abroad in the United States. A more developed making eco-system in the UK that had a higher number of accessible making mentors could provide valuable support for increasing making activities.
Cyber security and IP protection	Consultation with industry experts highlighted the risk involved in sharing data with people external to the organisation, both in terms of cyber security as well as IP protection. This risk is a deterrent particularly for large businesses that may have the potential to participate in making activities but currently are not. For example, these businesses are increasingly digitizing the value chain, which involves sharing information from the R&D process with external suppliers of intermediate parts. Without greater assurance and protection around cyber security and IP, the	Cyber security and IP protection are important components of the wider making ecosystem that need to be support to convert more businesses to making activities, including large businesses.

[45] Nesta (2015), Open Dataset of UK Makerspaces a User's Guide: ***https://www.nesta.org.uk/sites/default/files/open_dataset_of_uk_makerspaces_users_guide.pdf***

Challenge faced	Relevance to Making	How to counteract
	shift towards adapting these making processes will be difficult.	
Measuring the value of collaboration	It was also noted that large manufacturing businesses which are considering changing their production process to incorporate making activities must justify the financial cost benefit of such changes. While the cost savings that can be achieved through additive manufacturing can be quantified, for example, it is more difficult to measure that the value will be of increased interaction and collaboration with customers and suppliers.	The case study on FirstBuild provides a good practice example of how large businesses can begin to adapt their production process to incorporate making activity, while also reducing risk and ultimately increasing the competitiveness of the business. Increased opportunities for collaboration between small making businesses or individuals with large businesses can facilitate more making activities and benefit both parties.

Source: Deloitte Analysis

Insight 19: The impact of making activities has the potential to increase and can be supported to do so by addressing the specific barriers facing makers as well as supporting the business eco-system. The greater number of individuals and businesses that are able to participate in making activities in the economy will contribute to increasing the productivity and long-run sustainability of the UK.

Appendix 1: Economic Modelling Methodology

The economic value of making in the economy today has been estimated by using a two-step process: the estimation of the total number of people actively involved in making and then modelling of their activity to estimate supply chain impacts.

The number of active makers in the economy today was estimated is described below.

First, a set of Standard Occupational Classification (SOC) codes were identified that were believed to reflect the occupations of those who are most likely to be engaging in making activities. These were identified by Deloitte as well as in consultation with making businesses interviewed as part of this research. The following SOC codes were identified: research and development managers, chemists, bio scientists and biochemists, mechanical engineers, civil engineers, electrical engineers, electronics engineers, design and development engineers, engineering professionals and software professionals.

A SIC-SOC matrix was then used to identify the proportion of making occupations in each sector of the economy at the 4 digit Standard Industrial Classification (SIC) code level. Naturally, some sectors contained no people employed in making occupation, while the remaining contained varying proportions. A total of 134 sectors (4 digit SIC) were identified as having some proportion of making occupations. This list was qualified to exclude those sectors for which there is little indication that making activity could be occurring or have the potential to occur.

The remaining sectors with making occupations used in this analysis are the following:

Sector
18.20 Reproduction of recorded media
25.40 Manufacture of weapons and ammunition
28.94 Manufacture of machines for txt, app & leather products
61.30 Satellite telecoms activities
72.11 Research & experimental development on biotech
74.20 Photographic activities
29.20 Manufacture of bodies for motor vehicles & trailer
28.30 Manufacture of agricultural & forestry machinery
26.60 Manufacture of irradiation & electro medical equipment
38.22 Treatment & disposal of hazardous waste
43.99 Other specialised construction activities
58.11 Book publishing
28.41 Manufacture of metal forming machinery
20.59 Manufacture of other chemical products
10.89 Manufacture of other food products
28.25 Manufacture of non-domestic cooling & ventilation equipment
20.42 Manufacture of perfumes & toilet preparations
11.05 Manufacture of beer
30.11 Building of ships & floating structure
42.99 Construction and other civil engineering
20.30 Manufacture of paints & related products
42.11 Construction of roads and motorways

28.29 Manufacture of other general purpose machinery
74.10 Specialised design activities
33.16 Repair & main aircraft & spacecraft
25.62 Machining
24.10 Manufacture basic iron, steel & ferro-ally
26.30 Manufacture of communication equipment
30.20 Manufacture of railway loco & rolling stock
72.19 Other R&D on natural sciences & engineering
62.01 Computer programming activities
60.20 TV programming & broadcasting activities
71.12 Engineering activity & related tech consultancy
30.30 Manufacture of air & spacecraft & related machinery
42.12 Construction of railways & underground railways
63.11 Data processing, hosting & related activities
42.22 Construction utilities for electricity & telecom
28.11 Manufacturing of engines & turbines
29.10 Manufacture of motor vehicles
58.29 Other software publishing
41.20 Construction of res and non-res buildings
20.13 Manufacture other inorganic basic chemicals
21.20 Manufacture of pharmaceutical preparations
26.51 Manufacture instruments for measuring, testing & navigation
71.20 Technical testing and analysis
72.20 R&D on social science and humanities
59.11 Motion picture, video & TV programming and production activities
21.10 Manufacture of basic pharmaceutical products
26.20 Manufacture computers & peripheral equipment
74.90 Other professional, scientific & tech activities
61.20 Wireless telecommunications activities
26.11 Manufacture of electronic components
19.20 Manufacture of refined petroleum prod
61.10 Wired telecommunications activities
27.90 Manufacture of other electrical equipment
86.10 Hospital activities
73.11 Advertising agencies
29.32 Manufacture other parts for motor vehicles
86.90 Other human health activities
58.19 Other publishing activities

The proportion of making occupations within each sector was then applied to total employment in that sector using the Business Register and Employment Survey (BRES) data to obtain the total number of potential makers. This analysis assumes that only a certain proportion of the people who have the potential to make are actually making. Varying proportions of 10%, 25% and 50% were then applied to the number of total potential makers to obtain the number of potential active makers in the economy.

The number of active makers in each sector of the economy was then modelled to calculate their impacts in terms of Employment, GVA and Expenditure in London and the UK. An input-output model was used, which takes the latest available Domestic Use Matrix from ONS. The Domestic Use Matrix is used to provide a matrix of coefficients

that detail the proportion of inputs sourced by an industry from all other industries and labour, as well as the sourcing preferences of consumers. This is then subtracted from the identity matrix and inverted to give the Leontief Inverse, which can provide Type I multipliers. This multiplier can be used to determine the additional impacts of indirect/ supply chain employment.

The supply chain impacts were then subject to a further sense-check to provide a lower and upper range. This is due to the fact that making activities which are more digital in nature are likely to have a different (and potentially smaller) supply chain impact. For this reason, it is very difficult to accurately measure the specific sectors in which supply chain impacts of making activities will be felt. Nevertheless, if the supply chain impacts of making activities are analysed and do not account for the likely impacts of increased digitisation, the sector breakdown is as shown below. These figures provide the upper-end estimate of supply chain impacts of making activities.

UK			London		
Sector	No. supply chain jobs	% of estimated supply chain jobs	Sector	No. supply chain jobs	% of estimated supply chain jobs
Public administration and defence services	16,100	10%	Public administration and defence services	1,000	13%
Construction	15,900	10%	Education services	800	10%
Education services	13,900	8%	Construction	500	7%
Employment services	9,200	6%	Employment services	500	6%
Wholesale trade services	8,700	5%	Architectural and engineering services	400	6%
Wholesale, retail trade and repair of motor vehicle	7,200	4%	Services furnished by membership organisations	500	6%
Architectural and engineering services	6,800	4%	Computer programming	300	4%
Fabricated metal products	6,300	4%	Services of head offices and management consulting services	300	4%
Computer programming	4,500	3%	Services to buildings and landscape	300	4%
Services to buildings and landscape	4,300	3%	Legal services	200	3%
Other	71,100	43%	Other	2,800	38%

Source: Deloitte Analysis

To account for the increase of increased digitisation of making activities and thus different supply chain impacts, the Type 1 multiplier was applied to direct making activities based on the assumption they are occurring in the computer programming sector of the economy. In other words, the quantum of making activities (jobs, GVA and expenditure) were assumed to all be occurring in computer programme as opposed to the range of sectors identified above. While we know this is not accurately reflective of making activities, it provides an end-range of supply chain impacts for digital economic activities.

In this case, the supply chain impacts of making activities were as follows:

UK			London		
Sector	No. supply chain jobs	% of estimated supply chain jobs	Sector	No. supply chain jobs	% of estimated supply chain jobs
Employment services	18,000	15%	Employment services	900	16%
Education services	17,000	14%	Computer programming	600	11%
Services to buildings and landscape	10,400	9%	Education services	600	10%
Computer programming	8,900	7%	Services to buildings and landscape	500	9%
Architectural and engineering services	6,700	6%	Service of head offices	400	6%
Services of head offices	6,000	5%	Legal services	400	6%
Wholesale and retail trade and repair services of motor vehicles and motorcycles	4,200	3%	Accounting	300	5%
Public administration	4,100	3%	Advertising and market research	300	5%
Advertising and market research	3,900	3%	Security and investigation services	200	3%
Security and investigation services	2,400	2%	Services auxiliary to financial services	200	3%
Other	40,000	33%	Other	1,500	27%

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