Government Office for Science

Foresight

Which business models might ensure UK value from emerging sectors?

Future of Manufacturing Project: Evidence Paper 33

Foresight, Government Office for Science

Which business models might ensure UK value from emerging sectors?

By

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October 2013

This review has been commissioned as part of the UK Government's Foresight Future of Manufacturing Project. The views expressed do not represent policy of any government or organisation.

Contents

Executive summary

For the purposes of this report, manufacturing is treated in an inclusive manner, extending from R&D to recycling and re-use. The way in which the central activity of production (i.e. material conversion to create products) is linked to these other activities is considered central to business model innovation. Business models are the means to create and capture value, linking technologies to a market offering via a network architecture. The concept of network architecture takes business models to be inherently inter-organisational and is concerned with the ‘division of labour’ between organisations, structurally and, with the UK focus of the report in mind, geographically. Value is treated as being created in interactions between organisations in networks, rather than created solely within organisations linked together in linear value-chains. Value will also increasingly encompass environmental and social sustainability as well as financial elements. UK manufacturing predominantly adopts a business model based on production and sale of products within this linear value-chain logic, and this is in many ways under threat.

Services are considered as an important form of business model innovation. Currently, UK manufacturers are extending into service-enhanced market offerings, but often at levels so low that they may actually undermine value, according to recent academic studies. This is especially so for smaller firms and firms in ‘upstream’ sectors such as materials. Despite concerns about offshoring, the network architectures of UK manufacturers overwhelmingly retain the central activity of production solely within the UK. There is an intention to gradually increase the extent of production offshoring, but manufacturers also attach great importance to keeping design and development co-located with production. Across industry sectors, manufacturing firms are the most active product innovators but, even so, only a third of firms are classified as such. Service innovation is much more inter-organisational in nature than product innovation and, especially, process innovation. Hence there may be a need to greatly enhance firms’ capabilities in interacting with network counterparts to bring about the types of innovation needed to develop new business models. It is difficult to draw international comparisons on business models as such, due to a lack of agreed definitions, measures and statistics. But, if the addition of services is at least in part an indication of business model innovation, the UK lags behind a number of international comparator nations, with the USA by far the most advanced. Further original data collection and analysis on this issue may be required.

Based on desk research and over thirty specially-conducted interviews, themes that will shape manufacturing business model development were identified. ‘Services’ being rather a broad and varied category, underlying drivers and rationales for different market offerings were explored. Offerings based on a more circular flow of products, including repair, re-manufacturing and collaborative consumption will become more prevalent, driven by an increased separation between ownership of products and their use, and by various environmental pressures. This could result in a manufacturing system where re-manufacturing and re-use is the norm, and origination of products from virgin raw materials, to be sold once and for all to the end user, is the exception. Market offerings will become imbued with a greater density of information relating to provenance, personalisation, and the history of use, ownership and repair. Products will also become generators of information in the course of their use. Such information has the potential to generate new sources of value, but also presents difficulties of property rights and privacy. New forms of value associated with environmental and social sustainability will become increasingly important, and firms and policy bodies must understand, exploit and influence the role of standards, accreditations and other mechanisms by which these forms of value are imputed and, therefore, captured.

Information technology will be the most pervasive enabler of business model innovation – it makes new network architectures and new market offerings possible, in conjunction with emerging general-purpose technologies that are more specific to certain uses. In the timeframe of this study i.e. forty years, unimaginable increases in capacity and speed of data storage, processing and transfer are likely. This has huge implications for manufacturing processes and their location, the shape of future enterprises, the nature of offerings themselves, which will be much more information-dense, and for the role of physical products within IT-enabled value-creating ecosystems. General-purpose technologies related to materials and techniques will continue to develop, and it is important to rapidly identify and develop novel applications that go beyond using them to replace existing technologies in existing applications. This is likely to be an inter-organisational endeavour, for which suitable facilitating vehicles need to be designed.

UK manufacturing is dominated by small firms, and the already modest number of large firms will continue to decline. Networks coordinated by large, lead firms will give way to less hierarchical collaborative communities, with a greater role in innovation for small and, especially, medium-sized firms. Although some activities such as back-office services will be outsourced in a relatively ‘arm’s length way’, the most critical sites of value-creation will become the interactions between specialised firms, rather than processes within the firms. This again points to the importance of developing the capabilities of firms and their managers to access, interact with, and create and capture value with other firms in their networks.

Future business model innovation will bring together these themes and it is recommended that medium-term developmental domains be used as ‘work-outs’ to experiment with and drive new business models. These domains may revolve around specific locales, application areas or groups of associated technological projects. They could be seen as Business Model Catapults, since conceptually they have similarities with the existing TSB Catapult Centres, but a different focus. These domains can be used to develop a number of connections, which are considered essential to future business model innovation in manufacturing:

- Connect products to services, extensively, and in ‘upstream’ sectors as well as in complex product sectors
- Connect technologies to potential future application areas and needs, widely drawn
- Connect products to information, institutions and individuals, to create value
- Connect – and disconnect, as necessary – firms to one another in collaborative communities
- Connect the forward and reverse flows of products in a circular economy
- Connect technological and operational capabilities with entrepreneurial insight and action
- Connect firms’ business models to one another

1. Definitions and key concepts

1.1 Manufacturing

What constitutes ‘manufacturing’? According to Pavitt, manufacturing in advanced economies is surrounded by intimately linked, high-skill activities, the ‘…skilled activities that manufacturing firms undertake except manufacturing itself’; he adds that ‘...the fact that most of these activities are defined as “services” often confuses rather than clarifies’ (Pavitt, 2003: 88). What is meant by ‘manufacturing itself’ is rather elusive; it will be assumed to mean the active and deliberate changing of the form of materials. The ‘intimate linking’ of other activities to manufacturing itself is a critical concern for this whole study. Where do we draw the line between these service-like activities and other, less ‘intimately-linked’ services? The definition provided in the project specification is:

“Manufacturing is a system of value creating activities required to develop, produce and deliver goods and services to customers. Activities may stretch from R&D at one end to recycling at the other.”

For the purposes of this report, ‘services’ are taken to comprise those services necessarily connected to a manufactured product. Rather than settling on any once-and-for-all definition of what is ‘in’ and what is ‘out’[1], it will be suggested that constructing, exploiting and selling particular links between ‘manufacturing itself’ and other activities, and making these links tradable and valuable is precisely what business model innovation in manufacturing is about. It therefore may be the key to creating and capturing value for the UK.

1.2 Business models

Business models and business model innovation

Business models describe how organisations create and capture value. They are distinct from strategy, because they emphasise the internal logic of a business activity rather than comparing an organisation to its competitors (Chesbrough and Rosenbloom, 2002). They are inherently inter-organisational: for example, Zott and Amit equate business model design to ‘the design of an organization’s set of boundary-spanning transactions’ (Zott and Amit, 2007, p181). Furthermore, the business model concept conveys a sense of something that is more than the sum of its parts, and that embodies a significant element of intuitive entrepreneurialism: according to Chesbrough and Rosenbloom (2002), "a successful business model creates a heuristic logic that connects technical potential with the realisation of economic value". The term business model came into widespread use during the emergence of e-business. Timmers (1999, p32), an early analyst of e-business defined it as:

“An architecture for product, service and information flows, including a description of the various business actors and their roles; and a description of the potential benefits for potential actors; and a description of the sources of revenue.”

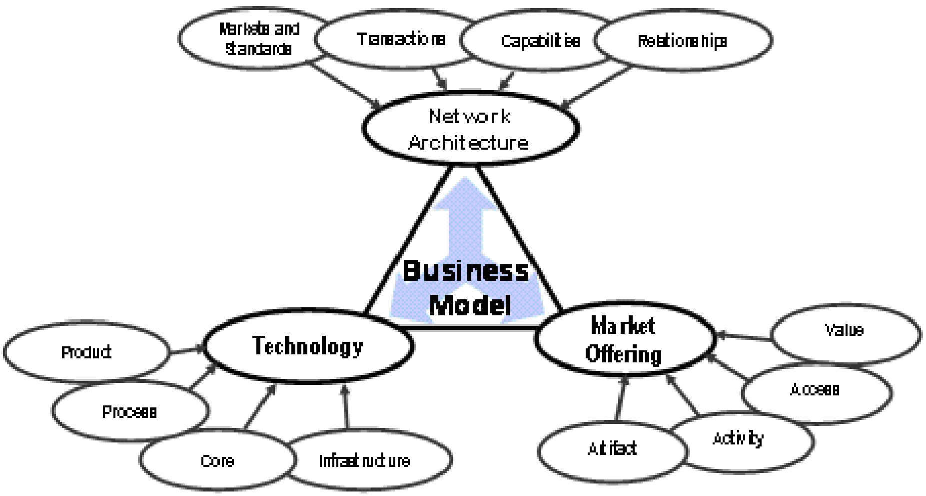
[1] In the interviews, the interpretations ranged from one very inclusive extreme to the other, very reductive one.

Nothing in this definition is specific to e-business and, indeed, the term ‘business model’ has now become widely used in all sections of business, and beyond. For example, business model writers Amit and Zott’s early publication (Amit and Zott, 2001) was devoted to e-business, but their subsequent work has been concerned with business models more generally (e.g. Zott and Amit, 2008). The business model literature has moved from a focus on what business models are, to business model *innovation*. A 2007 study by IBM Global Business Services, for example, found that the highest performing firms (across various sectors, not just manufacturing) give proportionately more emphasis than their peers to business model innovation (Giesen et al 2007).

The business model framework

The Mason and Spring (2011) business model innovation framework (Figure 1.1 and Box 1) brings together many aspects of the existing definitions of business models and will be used as the basis of the rest of this study. It emphasises the inter-organisational nature of business models present in Timmers, and in Zott and Amit, through the network architecture, and the emphasis on translating technology into economic value, present in Chesbrough and Rosenbloom. The third main element is the market offering which, rather than being simply an ‘end product’ (or service) ‘delivered *to*’ a customer, is a vehicle for value co-creation *with* the customer (and other network actors) - in keeping with the understanding of value discussed below.

Figure 1.1 Business Model Framework (Mason and Spring, 2011)



In the framework, the business model captures the interplay of these factors, reflecting the ‘heuristic logic’ of business models as per Chesbrough and Rosenbloom (2002). For example, using capital equipment on an access basis, such as the well-known Rolls-Royce ‘Power-by-the-Hour’ offering, requires new process technology and infrastructural technology to capture real-time usage data in the field, and requires the development of ways to transact metering technology and appropriate units by which usage can be charged. Business model innovation requires innovation on several ‘fronts’ at once, and an innovation in one area can set off a chain of innovations: for example (see Box 2 on Recorded Music), the invention of coin-operated payment (transactions) in the late 19th century enabled a new, access-based market offering in the form of phonograph parlours, rooted in the core and product technologies associated with sound recording. Finally, since business models are inter-organisational, interconnected organisations’ business models must co-evolve.

Box 1 - The Business Model Framework

Technology consists of:
- **core technology**, the technology underlying the functionality of an offering (such as a key raw material or functional component);
- **product technology**, the embodiment of a particular product or group of products, including core and other technologies
- **process technology**, the equipment, systems and organisational processes used to produce and deliver the offering
- **infrastructural technology**, by which offerings can be delivered and organisational units can connect with one another (most obviously the internet, but also containerised shipping etc)

Network architecture refers to the way organisations connect with and interact with one another, and the factors affecting that. It consists of:
- **markets and standards**, which determine the ease with which inputs and complementary offerings can be accessed from other firms rather than having to be provided within the firm
- **transactions**, meaning that the technical and institutional means to count and pay for that which is to be transferred between firms
- **capabilities**, the ability to carry out certain activities particularly well, which also determines the respective roles of actors in a network
- **relationships**, which complement market-based transactions as ways to bring about inter-organisational activity

The **market offering** captures the various ways in which products and their related 'services' can be made available to customers, and consists of:
- **artefacts**, the physical product(s) itself
- **access**, arrangements whereby physical and organisational assets are used by the customer rather than owned by them (e.g. lease or performance-based approaches)
- **activities**, which are carried out by the supplier(s) on assets owned by the customer
- **value**, which is concerned with what value is created by the offering, and for whom; for a variety of reasons, different 'bundles' of artefact, activity and access around the same product will be valued in different ways by different customers.

Box 2 - Recorded Music Business Models in History (based on Mason and Spring, 2011)

The early years of the sound recording industry show business model innovation very well. Edison's original invention of the phonograph in 1877 was not made with any specific use in mind. Having achieved the ability to record and playback sound, Edison speculated that it might have many uses including: recording the last words of dying relatives, business dictation, music recording, and use as a telephone answering machine (the telephone itself had recently been invented). The very early commercial uses of the phonograph were for its novelty value, with travelling showmen demonstrating it as a spectacle for which customers paid. In this sense, the phonograph formed part of an entertainment service offering. As the technology improved and stabilised, the next major use was as a business dictation machine. The business model here was for machines to be leased to commercial customers through a network of agents. As it turned out, although the technology had improved, it was still cumbersome to operate and maintain and many users did not renew their leases. At this point, being burdened with an inventory of phonographs, the agents identified a new use for the technology: recording and playing back music. Aided by the contemporaneous invention of coin-operation mechanisms, phonographs became widely used in phonograph parlours, where customers would pay, by a self-service mechanism, to listen to pre-recorded tunes.

Within a year, music overtook business dictation as the major revenue for the phonograph. From a business model point of view it is worth noting that the network of agents, not Edison, was an important source of entrepreneurial insight into the possible commercially viable uses of the technology. Furthermore, this commercial application was only possible because of complementary technological innovations such as coin operation mechanisms, as well as the developing capabilities of the consumer in accessing and operating such novel forms of entertainment (Langlois and Cosgel, 1998). Still further, the supply and use of a wide range of music on pre-recorded cylinders was only possible by the stabilisation of the production process and the standardisation -- and therefore interchangeability -- of the cylinders themselves. In more abstract terms and relating this back to the framework for business model innovation, transactions, standards, product and process technologies had enabled the network to provide a simple and cheap-to-operate, self-service market offering.

At this stage, phonograph equipment was too expensive for the typical consumer to buy. So the service-based offering was a way to enable access to entertainment otherwise inaccessible to the mass market. Subsequently, as the production costs and therefore prices of sound playback equipment and recorded media decreased, it progressively became within the means of first the affluent customers and then the mass market to own record players and to buy their own recorded music. As that happened, the business model effectively shifted from a service based offering (i.e. payment to access a capital asset) to an artefact-based offering, whereby consumers own the equipment and the recordings, and a large-scale manufacturing and distribution supply chain was created to serve them.

Although the media changed from cylinders to discs and then to compact discs, this model endured until the rise of file sharing and downloading of MP3s. This model -- the contemporary model for the distribution of music and, indeed, film and TV -- is in turn enabled by the infrastructural technology of the Internet and the widespread ownership of, and capabilities in the use of, personal computers. Although lagging the technology somewhat, the other important enabling development is in the institutional and transaction-making mechanisms that seek to protect property rights and secure revenue for the various actors in the network. Record stores and CD-pressing facilities are disappearing. The past 10 years have, in effect, seen a new industry attempting to construct a business model after the fact, following a major change in infrastructural technology i.e. the Internet and the development of enabling product technology and associated artefacts in the form of MP3 players such as the Apple iPod. In some ways the MP3 player followed in the footsteps of other personalised music players such as the Sony Walkman, but the latter still depended on physical artefacts i.e. tape cassettes and the associated production and distribution chain.

Business models and manufacturing

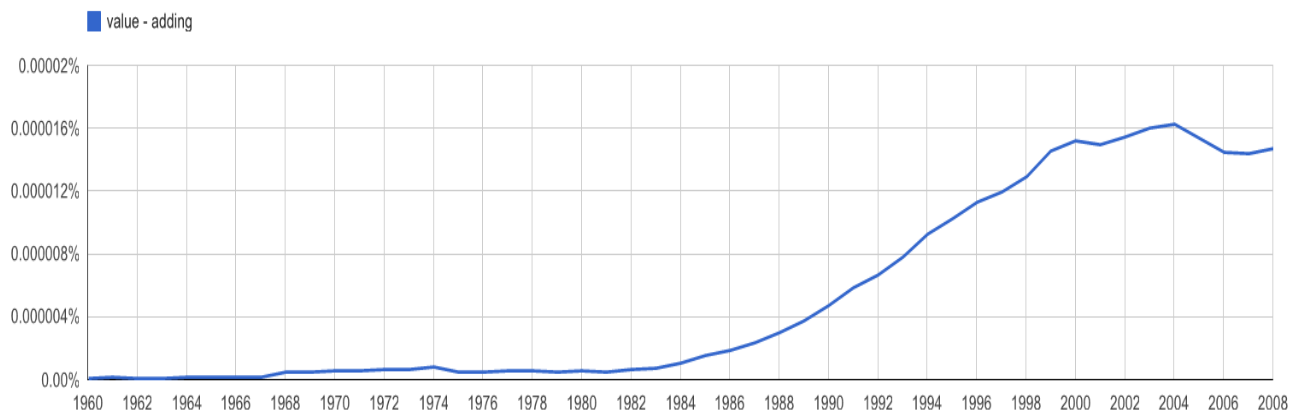
Business models are increasingly relevant to manufacturing. This is because the default business model in many areas of manufacturing industry, whereby a firm designs products, carries out significant material conversion itself and then simply sells the products to the customer, is difficult to sustain in the UK. Business customers and consumers alike are increasingly reluctant to take on the economic and environmental liability that ownership of a product may entail; they often also have many alternative sources from which they can simply buy things, and want sources and forms of value that exceed mere ownership of a product. Information and communications technology means that there are many new possibilities in terms of what forms of value can be provided, how it can be provided and by who, and where activities can take place. Through outsourcing, developing economies present huge, low-cost, international sources of capacity for manufacturing and other inputs such as engineering and R&D. From all directions then, the default UK manufacturing business model is under stress.

1.3 Value

Value and the Value-chain

The aim of this study is to ensure value for the UK from manufacturing, and value plays a central part in the various definitions of business models. However, value is a multifaceted and contested notion. Recent studies of manufacturing have used the concept of the value-chain, emphasising that manufacturing should be considered as encompassing R&D, distribution and associated services, as well as production (BIS, 2010a, OECD, 2007). Michael Porter's work in the 1980s has made the concept of the value-chain central to management thought, treating value as being added at each successive stage in a series of operations, conducted within one or more firms. The idea of 'value-adding processes' may seem enduring and uncontroversial: it is neither. 'Value-adding' as a term and concept only came to prominence since Porter's work: see Figure 1.2.

Figure 1.2 Google n-gram of usage of the term 'value-adding' – The 'Porter Effect'?



Other forms of value

The value-chain concept only takes account of financial value. However, other forms of value are important to the economy, as recognised in another recent study on UK manufacturing (RAEng, 2012). These include strategic value, in the form of enhanced capabilities, societal value in the form of, say, stabilisation of working communities, and value derived from satisfying aspects of corporate social responsibility. This report will return to these issues later.

Value is co-produced

The value-chain concept is also linear and unidirectional: R&D adds value, which then flows into production, which adds value, which then reaches the customer, who consumes the product. Or, focusing on the material flow: materials processors, then component manufacturers, then assemblers each add value, and then the product reaches the customer, who consumes the product. Roughly speaking, firms compete by adding more value at each stage, for less cost, than their competitors.

An influential alternative view is that, rather than being created by one economic actor and then passed to another, value is co-produced by interaction between actors. Furthermore, rather than taking place in a linear 'chain', this co-production occurs in a 'value constellation' (Ramirez, 1999, Normann and Ramirez, 1993)[2] – what we might now call an 'ecosystem'. The concept of the offering is central to this. Richard Normann defines it as follows:

"Viewing the economy as a web of activities and actors linked in co-productive value creation gives us another, and I think more creative, view of the nature of 'offerings'. Offerings are artefacts designed to more effectively enable and organize value co-production. They are agents created by agents. Innovative offerings can reconfigure co-productive patterns for higher value creation' (Normann, 2001, p114)

So, for example, Apple receives payment and makes some profit when customers buy an iPhone. However, in combination with Apple iTunes and iCloud, the iPhone is an offering that various economic actors can congregate around: apps writers, mobile phone network operators, users, record labels and so on interact in various ways to create activities and exchanges that are valuable to them all. Among these, users play an active role in designing and configuring their own connections and valuable services.

The relationship of manufacturers, broadly conceived, to this idea of the offering, will be central to the analysis in this report.

Value results from valuation

In the Porter value-chain, value is simply what someone is willing to pay for an output. Even in those analyses that emphasise the 'co-production' of value, the big conceptual shift is about who creates value and how they do it, not what value is. It is important also to realise, therefore, that value is the result of processes of valuation.

To place a value on something, it is necessary to place it alongside other items that can be considered as members of the same category, and to compare it with them against some meaningful scale. For stable, mature categories, this is a predictable process. But new offerings create tensions in evaluative schemes. For example, Dyson introduced the 'bagless' vacuum cleaner at roughly twice the price of the existing market-leading upright vacuum cleaner. Its distinctive attribute was that it did not lose suction as time passed, whereas cleaners with bags did, because the bags became clogged up. But was it worth the price? In order to allow customers to value this, it was necessary to introduce a new basis for comparison. Existing manufacturers claimed that their machines were more powerful (which some were, initially); Dyson was able to respond by invoking a different

[2] Ramirez argues that the value-chain implies that the customer's role, in contrast to the producers' 'value-creation' activities, is to destroy value by consuming and using the product, and that this is institutionalised in various ways, for example in accounting conventions to 'write-down' the value of capital assets as they are used (Ramirez, 1999,p49), and even in the very notion of 'value-added tax'.

scale – the percentage of airflow lost per gram of dust collected. Of course, on this measure, Dyson was the best. More generally, valuation often involves bringing values that exist outside markets into play inside markets, by invoking scales that allow comparison. This will be important later in the report when sustainability is discussed.

Valuations may also change even as the technology or product being valued stays the same. For example, in the Portuguese cork industry, electricity has been generated from bio-mass by-products in similar ways for over thirty years. However, whereas once it was valued by the firm as a cost-saving activity, now, given the heightened interest in environmental sustainability, it is valued (a) in different ways e.g. as contributing to a reduced carbon footprint and (b) by a wider network e.g. sustainability NGOs[3].

Capturing Value

Of course, the objective of value-co-creation and valuation processes is to *capture* value for the firm, its employees, for wider society and, in the context of this report, the UK economy.(Teece, 2010). Value capture has been addressed most compellingly by Teece (1986) and by Jacobides and colleagues (Jacobides et al, 2006a, 2006b). The key question for them is the way in which firms link their own capabilities to complementary assets – whether to vertically integrate to control those assets, or to develop 'architectural advantage' by developing 'platforms' that protect the value of the firm's assets while stimulating competition for the complementary assets. Although this is a subtle argument, some brief examples can illustrate the general thrust. Manufacturers of shaving implements, as is well known, generate revenue and profit from the blades: they control both razor and blade capabilities and assets, and lock buyers in to buying blades by controlling proprietary interfaces and by innovating frequently. It is difficult for would-be competitors to provide genuinely competitive blades. In contrast, cars need tyres, but auto assemblers use standard interfaces (tyre sizes and specifications) in their designs, so as to stimulate competition among tyre manufacturers[4]. We will return to the importance of standards later.

Part of the development of a business model is to devise what John Seely Brown, formerly of Xerox, called the 'architecture of the revenues':

'…sometimes we must work particularly hard to find the "architecture of the revenues"…Here at Xerox, there has been a growing appreciation for the struggle to create a value proposition for our research output, and for the fact that this struggle is as valuable as inventing the technology itself.' (Chesbrough and Rosenbloom, 2002)

Hence, as well as the strategic aspect of selectively controlling important assets stressed by Jacobides, there are more everyday questions of how what is to be sold is defined and measured, and how transactions are made (Baldwin, 2008). Seely Brown's quote is used in relation to the 'invention' of the 'pay-per-copy' value capture method used by Xerox with the then-radically-new, but expensive-to-buy, Model 914 photocopier (Chesbrough and Rosenbloom, 2002); as already discussed, the invention of coin-

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[3] Current doctoral research by Mafalda Nogueira, Lancaster University Management School

[4] Incidentally, it is argued that the demise of the British tyre-manufacturing sector was in part a result of the UK automotive industry's slowness to move to a few, standard tyre sizes in their car designs: the tyre manufacturers were unable to benefit from economies of scale. McGovern, T. (2007).

operation technology made the phonograph parlour business model possible. Today we have Paypal and Amazon's 'One-click'[5].

1.4 Summary – value in manufacturing business models

Bringing these concepts together, we can see that capturing value for the UK from manufacturing can take many forms. Value might be captured through activities other than 'manufacturing itself', which might be offshored. Transactions, and therefore value capture, might be made for offerings that involve deep, enduring service interactions between various members of the network, as well as simply selling products. Value will be re-defined in many ways, coming to embrace sustainability and other facets. But, although production activities might be offshored, there remains a critical role for what one respondent termed the 'kernel' of technological understanding that is the basis for providing the performance and function embodied in a physical product. How other activities link to that 'kernel' is an important part of what follows.

1.5 Outline of method

This study draws on a combination of secondary sources, academic literature, existing primary research and over thirty specially-conducted interviews (see Appendix 1 for a list of individuals). Since 'business model' is a relatively new concept, and not a construct that is widely agreed, there are not standard classifications or typologies of business models that are recorded and counted in government (or any other) statistics. Hence, the approach has been to draw together cross-sector survey data on some aspects of current practice that relate to manufacturing business models, and to use them flexibly in developing each part of the argument. A recent BIS study, " Manufacturing in the UK: an economic analysis of the sector" (BIS, 2010a) gives a contemporary perspective on many pertinent issues.

Specific interview sources are not quoted or cited. Rather, specific points and general lines of argument presented by the sources have been used as cues to develop lines of thinking and exploration. Outlining possible futures in concrete terms, certainly as far as 2050, was beyond most of the interviewees. This is hardly surprising. However, the research has identified some ways in which more general drivers and issues may translate into possible business model implications.

In the presentation that follows, the original motivating questions are provided in boxes at the start of the relevant sections.

[5] Richard L. Brandt's recent book about the development of the Amazon business model is entitled 'One Click: Jeff Bezos and the Rise of Amazon.com', implying that the Amazon business model hinged on transaction technology.

2. Current manufacturing business models

1. What are the different forms of business models within the manufacturing sector?
a) Currently employed and b) Emerging

2. a) Where in the value chain/process is business model innovation occurring and why?
b) In which sectors/types of business is business model innovation occurring and why?
c) What impact is a) and b) having on manufacturing activities?

The business model concept is relatively new, and there are no definitions or typologies sufficiently widely agreed or established to allow data systematically to be collected, analysed and reported on the business model as such. Nevertheless, some attempts have been made to draw up typologies of business models. For example, Malone et al. (2006) studied all 10,970 publicly-traded firms in the US economy in order to determine whether some business models are more profitable than others. Their typology rests on property rights – what assets are owned by the firm, and what rights are transferred in a sale e.g. whether ownership is transferred completely or customers buy use of the asset for a limited period. As such, it is very similar to the way the Market Offering is specified in the business model framework introduced in this report: artefact, access, or activity (see Box 1). Overall, they conclude that business models, defined in this way, make a difference to performance using various measures. No one business model is clearly better than the others on all measures used.

Zott and Amit (2007, 2008) distinguish between novelty-centred and efficiency-centred business models. Novelty-centred designs focus on new ways to conduct economic exchanges, for example 'by connecting previously unconnected parties, by linking transaction participants in new ways, or by designing new transaction mechanisms' (Zott and Amit, 2007, p184). Efficiency-centred designs focus on reduction of transaction costs. These authors test the effect of these designs on the performance of entrepreneurial firms and find some evidence that novelty-centred business models lead to better performance, but efficiency-centred ones have no significant effect. Zott and Amit accept at several stages that there are other facets to business models, but reduce the designs to two types 'in the interest of building and testing a parsimonious theory' (Zott and Amit, 2007, p182).

Both of these approaches present at least two problems. They are extremely reductive, and so lose any sense of context, and omit facets of business models that others consider important – for example, while they attempt to reflect some part of how value is captured, they do not really address value creation. Secondly, despite being reductive, they still require the collection of original data by which to measure their particular characterisations of business models. Because of these limitations, rather than follow the lead of either of these studies, this report draws together data on those aspects of the business model construct for which useful data are available, and attempts to cover both value creation and value capture insofar as these data allow. These are organised within the Business Model Framework set out above, using the three overarching elements of market offering, technology and network architecture.

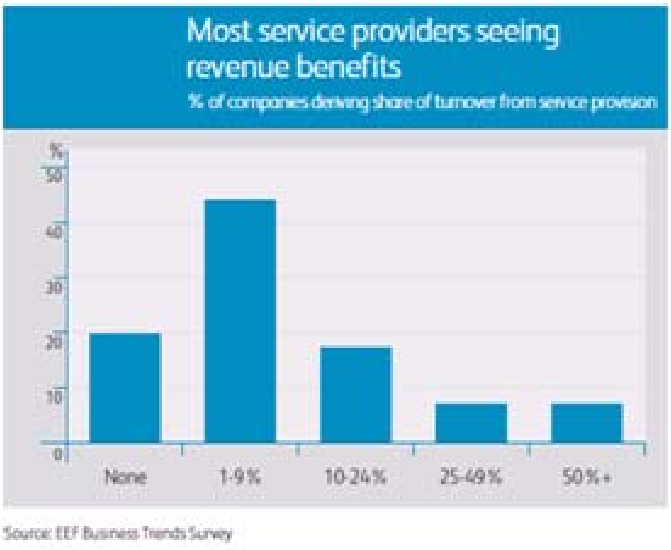
2.1 Current and emerging business models in UK manufacturing

The market offering: products and services

The market offering denotes whether value is created by transfer of ownership of an artefact, by provision of activities or by provision of access to an asset. Offerings are often combinations of these elements. For example, for some of its customers, Rolls-Royce sells an artefact (turbine) and sells activities (maintenance) separately. That is one market offering. For other customers, it sells access to the turbine, which it maintains at its own expense ('power-by-the-hour'). Activities and access could be classed as 'services' (Gadrey, 2000).

Hence, a useful indication of the market offering element is the extent to which manufacturers also provide services. A 2008 study by the EEF showed that 80% of manufacturing firms derive some revenue from services. However, in most cases this is only a small proportion: only 15% of firms derive 25% or more of their revenue from services. (See Figure 2.1)

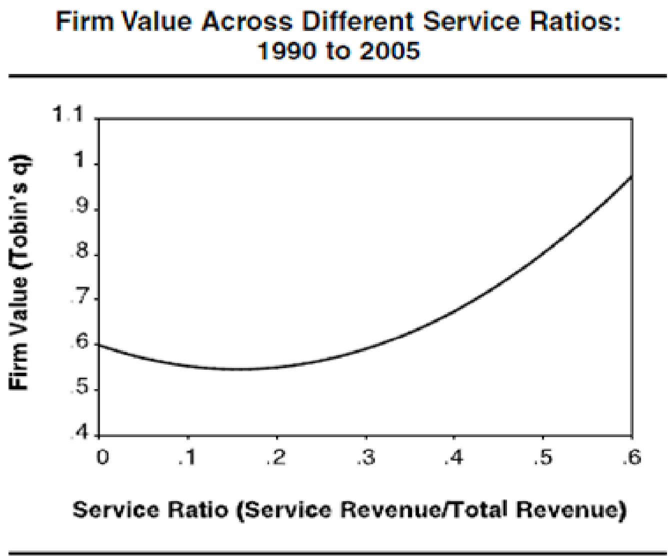
Figure 2.1 – Service provision among UK manufacturers



Fang et al. (2008) find that small extensions into services are worse than none at all. Studying a range of US manufacturing industries, they show that (a) firm value is initially reduced as services are added to products, only increasing firm value once service revenue constitutes around 30% of total revenue (see Figure 2.2) and (b) adding services has a much greater positive effect on firm value when services are closely related to the product, when there is otherwise low industry growth, or where there is high industry turbulence[6]. Neely (2008) similarly concludes that the profitability of 'servitization' is questionable. Suarez et al (2013), studying the software industry, conclude that software product firms who add services see profits decline until services grow to constitute a large majority of their total revenue.

[6] "For industry turbulence, we first calculate the standard deviation of sales in the firm's core product industry across the prior four years and then divide it by the mean value of industry sales for those years." Fang et al, 2008, p7

Figure 2.2 – Effect of Service Ratio on Firm Value (Fang et al 2008)



Thus it appears that a large part of UK manufacturing is doing exactly what the evidence suggests it should not – entering into service provision, but half-heartedly. A clearer understanding of different forms of service, the associated business models, and the measures necessary to develop them is, therefore, a theme of later sections of the report.

Technology

Technology can be characterised in several possible ways. One is to use classifications based on the underlying or 'core' technology of a firm or industry: metals, electronics, biotechnology and so forth. Indeed, this is how some of the emerging sectors might be identified. But of far more importance and general relevance for business models is whether the focus of technological innovation is on product, process, service or other innovations, and the disposition of sources of innovation. A recent BIS study (BIS, 2010c), drawing on the Community Innovation Survey, examines these issues. Some relevant findings are summarised here.

The study defines as 'innovation active' any firm that has introduced a new or significantly-improved product or service, undertaken incomplete innovation projects, or made significant expenditure in areas related to innovation such as R&D, training or equipment. Using this definition, manufacturing firms – engineering-based and other – are the most active product innovators, and are among the most active process innovators. Even so, only a third of manufacturing firms are product innovators, and only 18% are process innovators. Across all sectors, just under half of product innovations involve external organisations, whereas approximately 65% of service innovations are inter-organisational. This is important for the development of service-based offerings in manufacturing: service innovation requires a more inter-organisational orientation. Process innovations tend to be more internally focused, with only 34% involving other organisations. Since many firms have engaged in process innovation through lean manufacturing and the like in recent years, there may be a dangerous legacy of inward orientation that hinders the inter-organisational approach needed for business model innovation. The development of capabilities in accessing external expertise, and in configuring business models on a fundamentally inter-organisational basis is, therefore, a theme of later sections of the report.

The data also show trends over three surveys (2005, 2007 and 2009) in various aspects of innovation. While there is a slight decline in innovative activity over the period, there is a much greater reduction in so-called ‘wider’ innovation, which includes changes in strategies, management techniques and organisational structures, with only 30% of firms in 2009 engaging in this type of innovation. This is where business model innovation will be apparent, if anywhere. Innovation-active firms have a significantly greater proportion of graduate employees, and engineering-based manufacturing firms have twice as many science graduates as do other manufacturing firms. This points to the enduring need to drive innovation through advanced education and training.

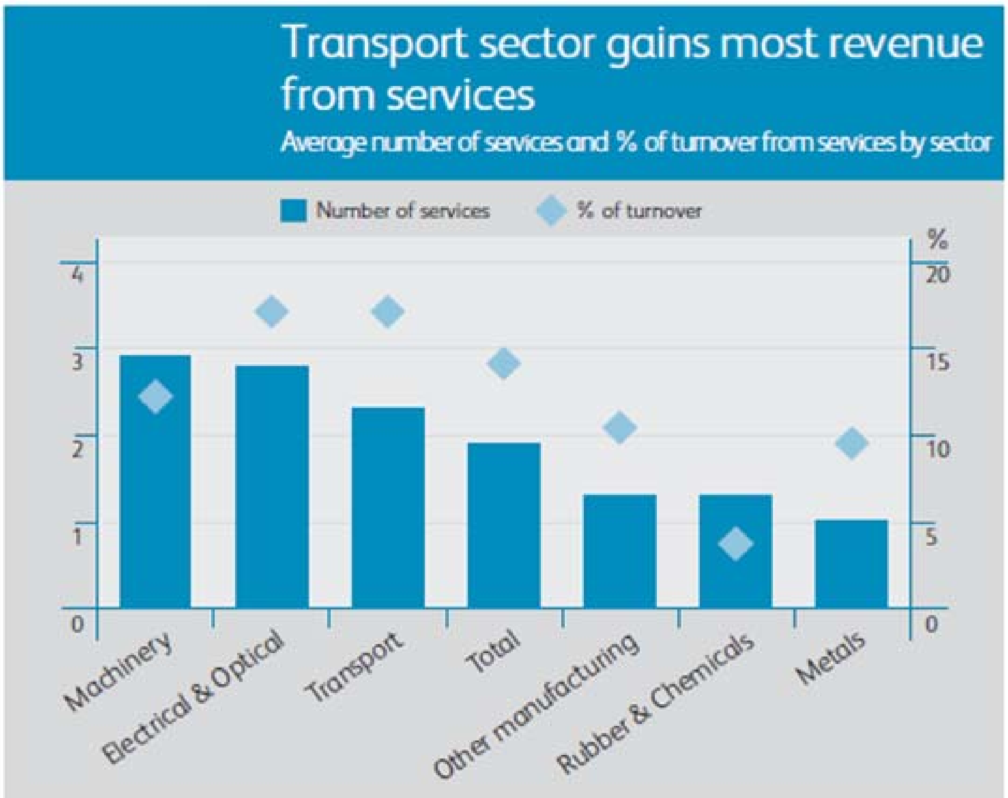
Network architecture

Network architecture concerns the division of labour between firms. Moreover, in the context of this report, there is an additional concern not only with what is done in which firm, but what is done in which country. To start at the heart of ‘manufacturing itself’, it is still the case that over 80% of UK manufacturers carry out production and assembly *only* in the UK, and fewer than 10% has more than half their production and assembly elsewhere (EEF, 2009). On the other hand, the importance attributed to production and assembly as a competitive edge, as compared to design & development and services, is declining. An important network architecture insight is the tight geographical connection between production and innovation: as production location moves overseas, innovation tends to follow it. Nevertheless, this is still an activity for a small minority of firms, since only 10% of UK-owned companies have innovation activities outside the UK. As at 2008, about 30% of firms intended to increase the extent of offshoring of production. There is some evidence of ‘repatriation’ or ‘backshoring’ of production, but only a small percentage of firms plan to reduce the extent of their overseas production.

2.2 Location and impact of business model innovation

The sale of services by manufacturers varies according to sector (EEF, 2008; see Figure 2.3). The rubber & chemicals and metals sectors provide fewer distinct services and generate lower proportions of revenue from services than firms in sectors that are, broadly speaking, closer to the final customer. This may suggest a relationship between position in established supply chains and the propensity to offer services. This pattern is consistent with the BIS study on innovation, which shows the primary sector to be the least innovative overall, with only half of firms classed as ‘innovation active’, compared to around 70% for all of manufacturing. However, a study of some 2000 firms in continental Europe (Lay et el 2010) provides contradictory evidence: firms at all stages of the supply chain are equally likely to generate sales from services.

Figure 2.3 – Sector Effect on Service-based Offerings (EEF 2008)



Source: EEF Business Trends Survey

Moving into services is closely associated with business model innovation: almost 50% of firms surveyed by the EEF claiming to have changed their business model. Furthermore, almost 40% cited changing the skills of the workforce and changing relationships with customers as necessary to achieve increased service activity.

Firm size is also important in at least two respects. Large firms – especially those with over 500 employees – offer more services. They also see a much greater role for collaboration with the firms in their supply chain than do smaller firms. It is particularly telling that 40% of small firms see *no role at all* for collaboration with their supply chain counterparts in the innovation process.

Reasons for business model innovation

If business model innovation is indeed occurring in larger firms and in sectors that are broadly 'downstream' i.e. in finished product sectors, rather than basic materials, then it is important to know why that is in order to proliferate these practices. Services are added, it is argued, to avoid commoditization, generate extra revenue, and for strategic reasons such as locking-in customers (Neely, 2008). From the customer's perspective, Cusumano suggests that services play three roles in relation to the products with which they are associated:

- Complementary/enhancing – making products accessible and maintaining them in use
- Complementary/extending – developing customer-specific uses and linking to other products

- Substituting – providing benefits of product without exchanging ownership (early and late in product diffusion process) (Cusumano, 2010, p79)

(Some of these are present in the music industry example discussed earlier – use of the phonograph was on a service basis in the early stages of the industry because the product was not easy to use, and was expensive to buy.)

Cusumano's three roles for services are more obvious in complex products, where customers may lack skills, capacity or inclination to maintain and customise them, and perhaps want to avoid the financial commitment of owning them. But for less obviously complex products and for materials, manufacturers have to work harder at creating suitable offerings, redefining, making new markets. For example, SKF, the Swedish bearing manufacturer, has successfully constructed service-based offerings around commodity-like products. This has been achieved by the use of complementary information technology embedded in products to collect data on the performance (Björkdahl, 2009), and the use of a patented software application that allows the firm to calculate and demonstrate to customers the value of extra services such as condition-based monitoring and technical advice (Anon, 2010). This is a service-based business model, constructed in part by re-defining value, and by engaging customers in a genuinely interactive process of value co-creation, rather than simply selling products. Of course, products are still sold, but the added services enable customers to reduce their in-house maintenance activities and therefore the SKF business model meshes - or can be made to mesh - with customers' own business model innovations. This suggests that not only do manufacturing firms need to innovate their own business model, but to develop a language and conceptual toolkit by which to articulate business model concepts with counterparts – to design a business model collaboratively just as readily as a new product.

We do not have extensive data on why smaller firms are less likely to have service-based business models. However, some extant case study evidence suggests that this may be a combination of firms' misguidedly providing some services, such as technical advice, for free (Anderson and Narus, 1995), and the typical SME complaint of extremely thinly-stretched technical and managerial resources. The latter point means that it is very difficult to devote attention to innovation at all, and that any attention that is given will be to the core product technology (note the large decline in 'wider' innovation since the financial crisis, reported above).

2.3 International comparisons and perspectives

Given that there are no established statistics for business model measurement, international comparisons are difficult. Nevertheless, it is possible to draw international comparisons on some aspects of business models in manufacturing, and to offer perspectives on business models from different countries. Again using the extent of provision of services as the best proxy we have for the market offering element of the business model, Neely's studies (Neely, 2008, Neely et al, 2011) offer some comparative insights. Both the 2008 and 2011 studies show US manufacturing to have the greatest proportion of servitized manufacturing firms. The UK had the ninth-highest level internationally, and from 2007 to 2011 this had increased from 24% to 39% of firms[7]. The

[7] This may appear inconsistent with the data from the EEF, which suggests that 80% of manufacturing firms derive revenue from services. However, Neely's classification is based on firms' descriptions of their own

extent of servitization had also risen markedly in other developed economies, e.g. Sweden, Norway and France, as well as in China – from 1% to almost 20%.
So far as technological innovation is concerned, the BIS innovation study (BIS, 2010c) is based on the UK element of the Community Innovation Survey (CIS), which comprises very similar surveys in other European countries. Insofar as the CIS provides useful information on the product, process and management aspects of business model innovation, comparative analyses along similar lines could be accessed from relevant countries of interest. This would, however, require additional analysis from the raw survey data.

Network architecture comparisons show in particular that, compared to the USA and Germany, UK manufacturing has very few large firms. Although fragmentation is likely to be a broad, longer-term trend (see below) and so firms will tend to get smaller, for the time being large firms seem to play an important part in innovation, both in their own right, and as catalysts for innovation in their network. Hence, the lack of large firms may necessitate other stimuli to innovation in general and in business models in particular, a possible role for policy interventions.

2.4 Summary of current manufacturing business models

- UK manufacturing firms predominantly create and capture value by manufacturing and selling products, with limited use of service-based business models. Some services are offered by most firms, but typically at levels that may actually undermine value, not create it. Firms in ‘upstream’, materials-based sectors, are the least service-oriented, as are smaller firms.
- Only a third of UK manufacturing firms are ‘product innovators’ and fewer still are ‘process innovators’. Levels of innovation in these technology areas are declining slightly, but levels of ‘wider’ innovation in organisation structure and management declined markedly in the 2005-2009 period.
- There is some evidence of UK manufacturing firms repatriating previously offshored manufacturing, but the overall trend is to offshore more.
- Larger firms collaborate with supply chain counterparts to achieve innovation much more than small firms do.
- It is difficult to draw international comparisons on business models as such, but UK manufacturing is behind a number of important developed countries in the development of servitized manufacturing; China is rapidly developing servitization and there is a sustained growth in offshoring of R&D and engineering design as well as more routine administrative work.
- The UK has a much smaller proportion of large firms than the USA and Germany and, since these have been important to innovation in their industries, it may be necessary to find mechanisms to replace the role of large firms as generators of innovation.

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activities in the OSIRIS database, and only classifies firms as servitized if they volunteer a description of themselves as offering services. As Neely notes, this is a conservative measure. It should also be noted that Neely’s data only includes firms with over 100 employees.

3. Future manufacturing business models

Which business models might be needed or will emerge to ensure the UK creates and captures future value from manufacturing activities?

3.1 Business models to 2050: themes and drivers

The challenge faced in this study is to get from a partial picture of the business models used in manufacturing now, to a vision of those that might be most effective in ensuring value for the UK in 2050. Anticipating how business models will develop in the next 5-10 years might be achieved by extrapolating from present technological and organisational developments, often in specific sectors. But a 40-year horizon is fundamentally, qualitatively different.

As such, it seemed highly problematic to ask questions of the form 'what will be the predominant business model for (say) clothing manufacture in 2050?'. First, the notion of business model is too new and inconsistently interpreted. Second, there are too many factors, operating over too long a period, to be able to forecast anything so specific. Therefore, the approach adopted was to ask respondents to speculate about long-run factors that might have a bearing on manufacturing, to complement and inform these discussions with theoretical analysis and secondary data, and to synthesize these various sources.

This section presents and discusses these themes. For presentational purposes, they are grouped under the three headings used in the business model framework. However, it will become clear that they interrelate a great deal – that is the nature of business models. After these have been discussed in turn, the report will explore how they can be used to project forward thirty or forty years to provide some insight into future manufacturing business models.

3.1.1 Market Offering Themes

The market offering of manufacturing firms is where value is co-created with the firm's customers, and is the basis for value capture. The market offering will become increasingly interactive, comprise various forms of what we currently term 'services', will be valued in new ways, many of which are associated with environmental and social sustainability; it will also be part of a circular, repair-based economy, rather than a linear, production-and-consumption-based economy. New market offerings will be the way to capture value from new technologies, and will be the basis for creation of new needs-based sectors. Some of these themes are now discussed in more detail.

Service-based models

The data reported above on adding services to products is an interesting early indicator of an emerging phenomenon. But, as for the economy as a whole, the category 'services' in manufacturing can cover a very wide range of activities: finance services, maintenance, custom design, performance-based solutions, and more besides. Although most are based on the 'kernel' of technological understanding, the routes to value creation and capture – i.e. the business models - are very different, as are the underlying motivations. Using the language of the business model framework, some 'services' are based on access: performance-based solutions, for example. Others are based on activities: e.g. maintenance of a product owned by the customer, or custom design. As such, the category 'services' may be too broad to be of much use.

So, while it seems likely that some or all of these will become more important parts of the manufacturing landscape, they play different roles in different situations and entail different business models. As such, it is more useful to examine some of the underlying drivers of these various services than to examine 'services' in general.

Repair, the Circular Economy, and Collaborative Consumption

In some sectors, typically involving capital goods such as transportation equipment, business models based on paying for access, whereby the manufacturer retains ownership of the asset and carries out maintenance, and customers pay to use it, are becoming more common. These have been motivated primarily by a desire for greater financial predictability: both of costs for the customer, and of revenue for manufacturers. Customers can also concentrate their efforts on their own core activities. Such arrangements also shift incentives: since manufacturers now bear the cost of maintenance and repair, they are more likely to design the products to reduce those costs.

However, these models based on non-ownership by the customer will extend into other sectors. Severe and growing material scarcity, combined with the growing costs and environmental impact of energy consumption and waste disposal make the original manufacture of products less obviously desirable than it was even twenty years ago. Customers do not want the financial and environmental burden of ownership and, as with larger capital goods, moving ownership to the provider shifts incentives to promote good stewardship. Models based on temporary or shared ownership achieve many similar ends, adding up to a shift from a linear economy to a circular economy, i.e. from an economy based on the conversion of raw materials into products that end their lives as waste, to an economy where products are re-used, 're-purposed', repaired, re-manufactured and recycled, rather than being used and discarded (Mulgan, 2013). This concept is nothing new, being set out by Walter Stahel over 35 years ago (Stahel and Reday, 1976/1981). However, recent impetus has been added by a number of think-tanks, including the Ellen MacArthur Foundation, focusing on the circular economy, and Collaborative Consumption (initially funded by NESTA). The latter focuses on developing business models based on shared use of assets, rather than individual outright ownership, facilitated by online methods for finding, booking and paying for use. While online tools can help make the mechanics easier, there is also the need to overcome institutional resistance to sharing (Mont, 2004): there are signs that, in both business and consumer sectors, this is indeed happening.

The circular economy can generate extra value for manufacturers, customers and other intermediaries (see Box 3 on washing machines), as well as making a significant environmental impact. Indeed, that impact is monetized by the avoidance of material costs, landfill taxes and other charges that will surely be increased as pressure on sustainability mounts. Value of other kinds can also be derived. Drawing attention to the general pre-occupation with original manufacture, Graham and Thrift suggest that repair and re-use are still unsung activities and could usefully take a more central role in our analysis:

"...perhaps we have been looking in the wrong place. Perhaps we should have been looking at breakdown and failure as no longer atypical and therefore only worth addressing if they result in catastrophe and, instead, as breakdown and failure as the means by which societies learn and learn to re-produce." (Graham and Thrift, 2007, p5)

Various forms of repair, improvisation and systemic engagement with and between manufactured artefacts - cars, bridges, roads, buildings, computer networks and so forth – therefore constitute opportunities for learning, development and long-term value creation. Repair often takes place in circumstances of the use of artefacts rather than of their production, in contrast to a business model based on offshored production of goods that are disposed of when replaced. Hence, it has huge implications for the location of employment and skills (again, see Box 3 on washing machines).

Re-manufacturing, whereby high-value or high-use parts of (typically) capital equipment are returned, repaired and re-sold, is carried out in aerospace, commercial vehicles, passenger cars, tyres, medical equipment to name but a few. Material scarcity, oil prices, extreme weather events and wider sustainability pressures may lead to a desire for greater self-sufficiency within the national borders, or at least within Europe. As such, one might envisage a manufacturing system where re-manufacturing and re-use is the norm, and origination of products from virgin raw materials is the exception. Re-manufacturing is also currently being used as a market-entry mechanism in developing markets e.g. by Volvo truck in India, where re-manufactured engines are sold at 65% of the price for a new engine. Re-manufacturing is becoming institutionalised through standards, and more products are being designed from the outset with re-manufacturing in mind. More generally, repair suggests different forms of offering, based on access and activity rather than sale of artefacts; it also requires different forms of connection between organisations, new technologies of product and process, and new ways of valuing. As such, it is both full of potential in its own right, and as a breeding-ground for broader capabilities in the longer-term.

Box 3 - Case Study: alternative business models for washing machines

The average domestic washing machine performs 250 cycles per year. Each machine contains 30-40kg of steel. Cheaper machines last 2000 cycles, i.e. less than 10 years, and have higher running costs. But short warranty periods mean that customers nonetheless often buy these machines.

If five cheaper machines were replaced with one more expensive machine that would last 10 000 cycles, this would save 180kg of steel and 2.5 tonnes of CO_2 emissions in production. If these last for twenty years though, customers might miss out on subsequent improvements in control systems that optimise programmes and efficient use of detergents, offsetting some of the material and energy savings.

The long-life, high-initial-cost machine is better for the environment. But the short time-horizon of most households, and other incentives, militate against this approach.

Although the 'low-end' purchase approach may involve some recycling of steel from the discarded machine, this is among the least effective ways to mitigate the environmental impact. More genuinely 'circular' approaches involve more radical changes in the business model.

One approach, which still involves individual households having the use of a machine, is to build higher-specification, longer-life, more efficient machines, which are leased to households. Recent analyses show that both manufacturers and households benefit financially by about 30% in comparison with the model based on the purchase of low-end machines. Thus an ‘access’- based offering generates and captures value for both manufacturer – and/or a specialist intermediary – and the household, as well as benefitting the environment.

This leasing approach can be combined with a programme of refurbishment – to replace the parts that typically wear quickest, and to upgrade control systems as technologies advance. This will reduce the demand for newly made machines, but create work in diagnosis and repair, and in the production of components for refurbishment.

ENVIE, a social enterprise in France, refurbishes and re-sells conventional white goods in order to provide a way back into work for long-term unemployed people. The refurbished machines are sold on to low-income households who would not otherwise be able to buy a machine. ENVIE partners with a wide range of organisations, including: machine makers and retailers, who provide used machines for refurbishment; social services, who can provide additional support to employees; energy suppliers; and a variety of local and regional administrative and environmental bodies. In this way, the washing machine or other white good’s passage through the circular economy becomes a platform for value-creation of a more multi-faceted nature, developing skills and work routines among its employees, and making new connections between them and various social institutions.

In Sweden, shared use of washing facilities has been a widespread practice since the 1930s, when the state made deliberate moves to liberate women from the most burdensome domestic chores in order to include them more fully in the paid workforce. Incorporation of these facilities in apartment blocks was mandated as part of the regulatory process, and energy efficient, high-specification machines are used in a collaborative consumption model, with residents using machines either as part of their service charge in the apartment, or on a pay-per-use basis. Internet-based booking systems make shared access practicable. Rather than being used 250 times a year as a domestic machine is, these machines are used thousands of times, maintained by third party service firms, and replaced or refurbished frequently (typically every three years), keeping them up to date with efficient control systems (Mont, 2004).

In these various ways, we see that alternative business models, involving new understandings of value (less value associated with ownership, more with service outcomes and with wider social and economic benefits), and multiple roles for a network of actors, can reconstitute the ‘washing machine supply chain’ as a value constellation, with alternative structures of ownership and transactions. The implications for manufacturing are many and varied: different washing machines are needed; there is more emphasis on diagnosis and repair as well as origination, creating service work, and incentivising design-for-repairability; depending on structures of ownership, there are increased incentives to use technology to maximise efficient, and therefore more sustainable, washing.

Sources: Ellen MacArthur Foundation; ENVIE website; Mont (2004).

Personalisation, Identity, Provenance

Connecting products (i.e. physical artefacts) to individuals, institutions and information is a widespread and, it seems, enduring trajectory in manufacturing systems. In mass production, sequential processes create standardised physical products, for which property rights are transferred to an owner, who then uses the product as they will, retaining a connection with the sources of the product only insofar as warranties and guarantees allow, and experience in use requires – typically not at all. Products are used anonymously and disposed of anonymously.

As IT makes it possible to identify and characterise individual people, places, organisations and things in a much more fine-grained way, new connections between products, individuals, institutions and information become possible, new sources of value become possible, and new business models arise. Note that connecting products to individuals does not mean cementing the bonds of ownership: with reference to the discussion above the greater ability to connect the physical artefact to information e.g. through measuring usage and linking to the identity (and bank account) of the user, makes it more, not less, feasible to operate non-ownership-based business models.

To take some examples:

Personalised medicine: much greater prognostic and diagnostic information on individual patients make it possible to manufacture personalised medication aimed at individuals or very narrow segments, rather than the mass market, and integrating this with individual patients' responses to treatment has the potential to turn a unidirectional drug production and distribution system into a bi-directional healthcare support system that happens to involve the creation of vehicles for the delivery of molecules i.e. medicines. There are huge challenges in determining who has rights to the prognostic, diagnostic and ongoing treatment information relating to individual patients, and who pays who for what.

Tracing safety critical components and products: It is commonplace for information on provenance to be associated with products in a more-or-less fine-grained way. Products may have batch numbers stamped on them to allow recalls in the case of quality problems (e.g. foodstuffs). For higher-priced products, individual serial numbers are used. As remote monitoring, information systems and institutional transparency develop, products increasingly become carriers and producers of more and more information. This will affect issues of provenance so that individual items, even relatively low-value ones, will carry or be linked to very detailed data about sources of material, circumstances of production, embedded energy and water, guarantees of authenticity and so forth (see para below on Sustainability and value). For higher-value components e.g. aerospace spares, exact details of production processes used are critical to ensuring authenticity, and subsequent examination of performance and failures in service; this is combined with historical and ongoing data regarding usage, maintenance interventions, etc. This will proliferate – more data will be generated and collected for high-value products, and this will become more feasible for lower-value products. Some have suggested that even for the most everyday objects, biological markers will ensure that ownership is traceable and this will militate against inappropriate disposal. Just as now one cannot dump a car without repercussions, because it is uniquely identified and knowledge of its ownership is institutionally recorded, there may come a time when the same would apply to a pair of training-shoes or even a drinks container.

Products as agents and generators of information: As many forms of product become 'informated' (Zuboff, 1988), physical artefacts become sites, at various stages of their lives, for the creation and capture of information. We see this now, for example, in the way smartphones generate location-specific data for and about their users. This has been characterised as the 'Internet of Things'. Kortuem et al. (2010) usefully distinguish between activity-aware, policy-aware, and process-aware 'smart objects', each of which represents a greater interactivity – with users and with other 'things'. A high-profile example of a 'process aware' object is the driverless car (Araujoet al, 2012), but opportunities abound in many more low-profile applications for process-aware objects to be used to supplement or replace human process management e.g. multiple monitoring devices in multi-stage, patient-specific medical care processes.

Such information-enhanced manufactured products – and the wider ecosystems in which they may exist – offer an enormous number and range of opportunities for additional value creation among network counterparts. But they also present potential problems, associated with property rights and privacy. If information becomes an increasingly valuable asset, it will become more important to understand the rights of those who create information, how to protect the ownership of the information, and how to safeguard the privacy of those to whom the information may relate. For instance, private sector road contractors may use telematic devices in cars to allow automated road toll collection, and to collect data on aggregate traffic patterns for road management purposes. But the data could have considerable commercial value to third parties (e.g. fast-food chains) and could be used to scrutinise individuals' patterns of movement and driving behaviour. These emerging issues of intellectual property right and privacy require further study and are indeed the focus of another parallel report.

Fabless manufacturing

The typical manufacturing business model captures the value created in development and design by the sale of products. 'Fabless' manufacturing captures value by selling the 'kernel' of technological knowledge *as knowledge*, leaving production to someone else. ARM Holdings is a well-known example of this approach. Fabless manufacturing may well offer benefits for some technologies at certain stages of their development. A key determinant of its appropriateness is the extent to which design and development knowledge can be codified and made transferable. This represents a major opportunity for manufacturers whose capability in repetitive material conversion is made less distinctive as developing countries' manufacturers gain these capabilities. But they have to shift from recouping expenditure on design and development through selling products, to selling the design and development in its own right. This requires a major effort in designing the market offering and re-defining their identity in the network, and in doing so in concert with their counterparts' business models (Spring and Araujo, 2013).

Sustainability and value

Environmental and social sustainability was seen by the respondents as the most pervasive long-term theme affecting future manufacturing business models. Although it is introduced here as a theme associated with the market offering, it has implications for all areas of the business model: as one of the interviewees said, almost in the first words of his first response: "There will only be sustainable business models". Sustainability is the underlying reason for many of the themes discussed in this section.

It might be argued that paying attention to environmental and social sustainability inevitably drives up costs and makes firms less competitive. However, sustainability will increasingly become (a) necessary to some level and (b) an important basis for differentiation and therefore for additional value-creation. Furthermore, in many respects, sustainability can *reduce* costs. There are parallels with the early days of Total Quality Management in 1980s manufacturing, when Crosby's notion that 'quality is free' (Crosby, 1979) seemed revolutionary. Now it is widely accepted that there is no trade-off between cost and quality, and the same will soon be said for sustainability. Indeed, there is already empirical evidence to support that conclusion: for example, a recent study shows that sustainable supply chain management results in improved firm performance on a range of financial and operational measures (Golicic and Smith, 2013).

Sustainability will come to be measured and managed in the way that quality has. This will be part of the mechanism for capturing value from sustainability. However, there are considerable challenges, arising from at least two major sources. The first is that the issues to be measured and managed in sustainability are often more difficult to identify, define and quantify than even the more subjective aspects of quality. The second is that the net often has to be cast very wide, because of the extended nature of design, production and distribution systems. Furthermore, there is presently considerable diversity and competition among the various schemes for sustainability measurement and accreditation. While ISO develop their schemes, other bodies e.g. Fairtrade have high-profile, 'branded' certifications and, in the USA, Walmart are developing a sustainability metric which, once established, is likely to become the *de facto* metric across retailing, in the US and maybe beyond:

"Walmart officials emphasize that their intention is not to "own" the index and consider its strength in success to be its design as a globally shared and open platform tool. The index will drive innovation, highlight opportunities for cost savings and waste reduction, and create a common playing field for all. Further, The Consortium will be able to track how the index is reducing environmental impacts and driving innovation and green jobs." (Arizona State University Website[8])

In the UK, the National Physical Laboratory is working with the Environmental Materials Information Technology (EMIT) Consortium to develop tools to allow the calculation, at the design stage, of new products' CO_2 footprint and energy usage. These tools are to be linked with widely used CAD (computer-aided design) software packages[9].

In these ways, then, the offering will come increasingly to be evaluated on the basis of such measures, as well as on more conventional price-performance parameters. There will be a jockeying for position among various schemes of accreditation for environmental and social sustainability. Just as with product brands – 'Intel inside' being a prominent example – the battle for branding of firms' and supply chains' sustainability credentials will be complex and critical (Duguid, 2010). Manufacturers will need to understand and, if possible, shape this process.

3.1.2 Technology themes

[8] http://sustainability.asu.edu/news/gios-news/arizona-state-university-and-the-university-of-arkansas-to-work-with-walmart-on-developing-sustainable-product-index-for-consumer-products-world-wide
[9] http://www.npl.co.uk/news/software-aids-sustainable-material-choices

Technologies underpin business models. A technology may provide the fundamental performance attributes that make products valuable, for example, graphene. Other technologies may make the business model through which the value is created and captured possible: for example, the internet makes offshoring back-office functions feasible. The overwhelming pervasive technological theme is and will continue to be information technology. This will be complemented by a number of materials- and process-based general-purpose technologies.

Information Technology (IT) - Infinite Bandwidth/Zero Latency

From a manufacturing business model point-of-view, IT is important as a core technology in products, and as an infrastructural technology affecting the way offerings can be made available, and how (and where) networks of organisations can be configured. In other words, it has profound implications for almost all aspects of possible future business models. Current developments show some prospects for the near future: cloud computing and widespread wireless networks in developed economies make it possible for organisations (manufacturers or service providers) to connect with ‘informated’ products (see above); informated products can connect with one another. Manufacturing-related activities such as engineering design are already being offshored on a large scale (Manning et al, 2008), due to advances in the internet’s data-carrying capacity. However, bearing in mind that this study is looking forward to 2050 – in round terms, 40 years – these emerging practices are probably very poor indicators of the longer-term implications of IT, of all things. Looking *back* 40 years, transistor count on CPU chips has increased by a multiple of about two million, from the Intel 8008 in 1972 with 2,300 transistors, to the 62-Core Xeon Phi in 2012 with 5 billion transistors. In just a few years, volumes of data have grown beyond recognition – 10s of trillions of objects are downloaded every year, including something like 2 billion photos per month. In 1972, the personal computer didn’t yet exist and the world wide web was twenty years away.

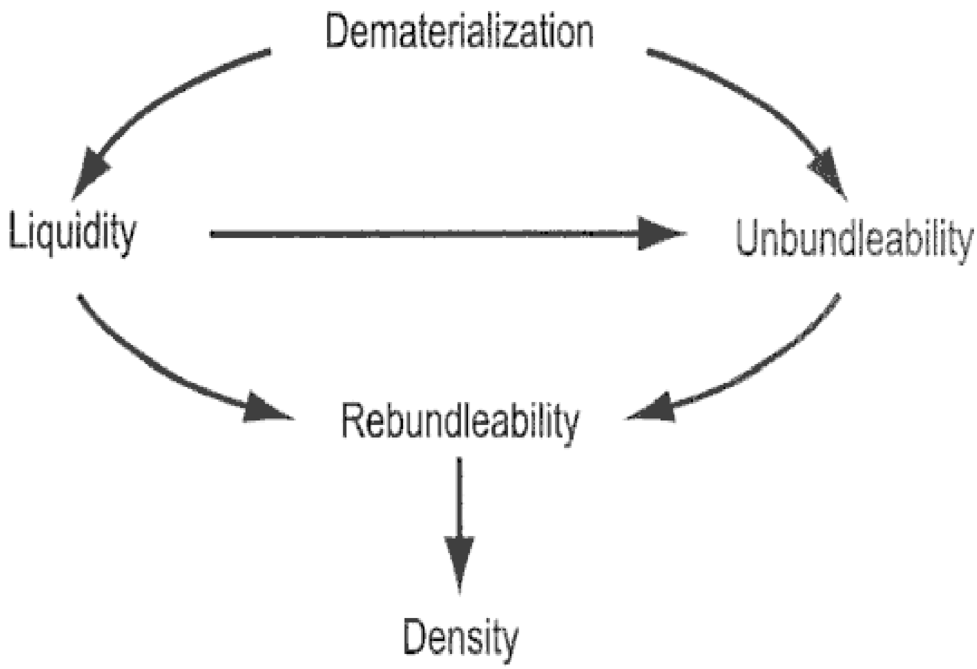
As such, some effort is needed to break free from potentially lame extrapolations of the present. One interesting approach to this is “Infinite bandwidth/zero latency” (IBZL), described as a compelling ‘thought experiment’ that “starts from the question: what if bandwidth (and latency) in networks like the internet didn't matter anymore? What would become possible?”[10] (See also Bell and Walker (2011)). The IBZL approach focuses on uses and applications rather than anticipated technical improvements in infrastructure. IBZL clearly removes obstacles to working across firm boundaries and across distances. But IBZL would also render feasible the dispersion of hugely data-transfer-intensive processes requiring telepresence. An illustrative instance of this is remote surgery, whereby a surgeon is able to operate via a robot which, crucially, is able to provide real-time sensory feedback to the surgeon which, in turn, requires hugely reliable data links and no time delays i.e. (approaching) zero latency. Telepresence will affect development and production processes of manufacturing, as well as create opportunities for new types of offerings.

[10] http://ibzl.net/

The 'Density Principle'

This is a concept introduced by Richard Normann (2001). It refers to the way in which technology, particularly information technology, can be used to bring together resources for a particular actor at a particular place and time, to give the best possible value/cost result. For example, an academic can search a half-remembered title of an article in Google Scholar, which links seamlessly to the university's library holdings (actually hosted on the publisher's servers) and, within seconds and a few clicks, have a digitally-annotatable pdf version of the article on a tablet computer, opened and interrogated using an app designed for the purpose. Twenty years ago this would have involved physically entering the library building, using (multiple) abstracting indexes in hard copy to find the article, finding the bound volume, taking it to the photocopier, copying it page by page, and then manually annotating it. To take another example, recent empirical studies of aerospace component manufacturing (Spring and Araujo 2013), show that part of 'moving into services' for one medium-sized manufacturing firm involves sophisticated, local and temporary integration of the CAD systems and designs of the customer, various IT- and non-IT-based technologies within the firm, as well as among suppliers, in order to deliver a rapidly-designed and made prototype. Both these instances involve aspects of dematerialisation – separating the physical artefact (written copy, the aero engine) from the information about it, moving the information around and reconfiguring it, then re-constituting it in a particular, valuable form (the annotated file on the tablet, the physical new prototype part). Normann (2001, p30) captures this in the diagram Figure 3.1.

Figure 3.1 – The Density Principle (Normann, 2001)



This means that services (possibly involving physical artefacts) are 'automated' and provided more quickly and cheaply. But, much more significantly, it also means that the roles of actors can be changed, activities can be fragmented between actors and across geographies (see infinite bandwidth, zero latency), re-integrated in new ways at new sites, and can be 'enabling' as well as 'relieving' i.e. can make it possible to do things that were not possible before.

Another way to characterise the density principle is provided by Chris Anderson, editor of *Wired*: the process of moving from atoms to bits and back again (Anderson, 2012). Additive manufacturing, or 3-D printing, is the most prominent manifestation of this at the time of writing, and some argue that it has potential to transform manufacturing across many sectors (Sissons and Thompson, 2012). Various industry structures are envisaged, including production in the home (either for personal use or for subsequent sale), in local 'printing' shops, and within more conventional centralised production facilities. Additive manufacturing can: enable personalisation; postpone production to the time and place of need, thereby reducing transportation, inventory and speculative manufacture; achieve geometries and composite constructions otherwise unachievable; reduce material waste, compared to traditional 'subtractive' processes; and make it economically viable to produce one-offs or very low volumes of items. In some instances, business models may not change much – products are still made for sale, just using a different process. However, where production itself can be left to the customer or to a local 'print shop', new transactions for new information-based offering must be defined and enabled, sometimes requiring the creation of new markets e.g. for the downloadable files that control the printer. This 'market-making' process requires the development of standards, definition of parties' legal responsibilities, and even reconsideration of planning zones, as high-street shops could become sites of significant manufacturing activity (Sissons and Thompson, 2012). Once again, although driven by technological development, the business model implications reverberate through market offering and network architecture as well.

General-purpose technologies

General-purpose technologies create new opportunities for value creation through new properties and levels of performance. But they are not the same as sectors or industries: "It is a common error to regard dramatic technological advances such as information and communication technologies or biotechnologies as 'industries', tied to particular product ranges. As their names in fact indicate, these are 'technologies': they represent high-tech activities that become pervasive in the guise of 'general-purpose technologies' (GPTs), and their adoption thereby spreads across a wide swathe of user 'industries'" (Robertson, et al, 2009 p441)

Given the long time-horizon of this study, it seems particularly important to be wary of this potential error. There probably will not be a biotechnology sector in 2050, nor a nanotechnology one. Or, at least, it seems that the most valuable economic activity in biotechnology and nanotechnology will not be in origination and manufacture of basic input materials, but in a wide range of application areas, most of which we can't imagine (See Box 4 on titanium).

Box 4 – Titanium

Titanium was discovered in the last decade of the 18^{th} century, but was not produced outside the laboratory until 1932, and was first used in aerospace applications in the 1950s. Now, about two-thirds of all titanium produced is used in aircraft manufacture. We do not typically speak of the 'titanium sector', but we do talk a lot about the aerospace sector. We talk about Rolls-Royce's 'power-by-the-hour' business model, somewhat taking for granted the everyday miracle of the engineering that makes, say, the Trent 1000 engine work at all. That miracle depends among other things on the mastery of titanium alloy technologies, and that has occurred over the eighty years since the metal emerged from the laboratory. This present study is projecting forward about half that period, so we should be wary of assuming that sectors based on contemporary high-performance material will still exist in anything like the form that they do now.

The relationship between these GPTs and business models, then, is that the GPTs provide the basis for value-creation, but the business model achieves value creation – and value capture. It is not possible or credible over such a period to predict particular business models for particular technologies. Business models are far too context-specific for that, and the range of technologies is vast. Many of the 53 technologies reviewed and discussed in a recent Foresight report (BIS, 2010b) are relevant to manufacturing.

Instead, we can use business model ideas to help expand the way we think about exploiting the potential of emerging technologies. Box 5 contains a short account of the prospects for graphene, a high-profile emerging technology. It is notable that all the conceptualisations of possible future uses for graphene – and this applies to many other emerging technologies – talk about product embodiment as the destination e.g. graphene being incorporated into flat screens. And yet, as the 'roadmap' discussion suggests, graphene's very novelty means that:

"its full power will only be realized in novel applications, which are designed specifically with this material in mind, rather than when it is used to replace other materials in existing applications."

As Robertson et al (2009) point out, high-tech sectors and firms depend on low and medium-tech (LMT) firms:

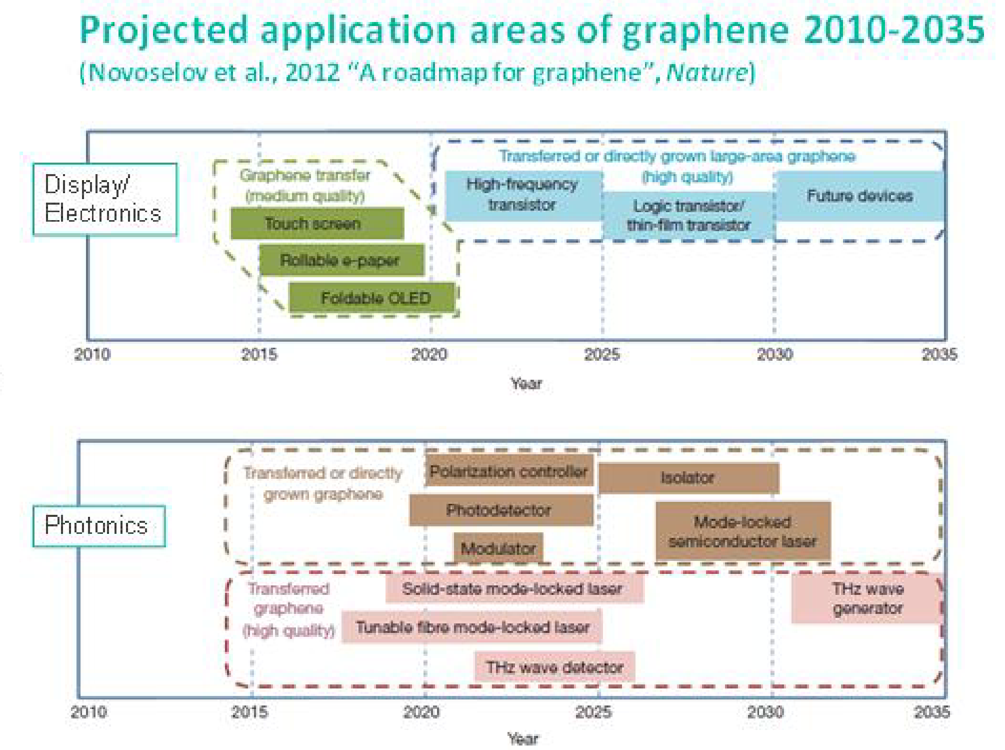
"With very few, if any, exceptions the outputs of high-tech sectors are only of value when used in conjunction with the outputs of other, less research-intensive, sectors. Conversely, innovation in LMT sectors generally involves the serial incorporation of high-tech components into existing products and production processes" (Robertson et al., 2009, p 441).

Value-creation and value-capture, then, depend on this articulation between emerging and mature sectors and, by implication, firms. Furthermore, with a broader concept of the offering in mind, value creation depends on the ability to generate the 'novel applications' for and from among users. This goes beyond finding product embodiments into which to insert the new technology as a replacement. This underscores the importance of the next theme area, network architecture.

Box 5 – Graphene

Graphene is an archetypal emerging technology (although it may or may not be considered 'disruptive' (IPO, 2011)). It has remarkable properties in respect of strength, conductivity and impermeability. A recent technology 'roadmap' for graphene (Novoselov, et al 2012) identified five basic production methods, the products of which vary in their quality and cost. So, some lower grades of graphene for applications such as paint additives are already available at relatively low cost and in volumes measured in tonnes. Other grades of higher quality, however, can only be produced in relatively small quantities at much higher cost. The 'roadmap' identifies the following application areas: display and electronics; photonics; composite materials, paints and coatings; energy generation and storage; sensors and metrology; and bioapplications. It is notable that, although the paper's authors represent the graphene science community – indeed, some of those who discovered it - and major corporations such as Texas Instruments, AstraZeneca, BASF and Samsung, their roadmaps of applications only extend to 2030 or 2035. This reflects the impossibility of projecting so far forward, especially with such a young technology. A contemporaneous market analysis suggests that the market for graphene in 2018 will be $100 million dollars, although the basis for making that claim is not clear. The ‘roadmap’ paper concludes:

“Graphene is a unique crystal in the sense that it combines many superior properties, from mechanical to electronic. This suggests that its full power will only be realized in novel applications, which are designed specifically with this material in mind, rather than when it is used to replace other materials in existing applications. Interestingly, such an opportunity is likely to be provided very soon with development of such new technologies as printable and flexible electronics, flexible solar cells and supercapacitors.”(Novoselov et al., 2012,p 199)



3.1.3 Network Architecture Themes

There are countervailing and complementary forces at work here. On the one hand, activities will become dispersed among more, smaller organisations; on the other, the ability to link activities interactively between these organisations will become more critical. Each is discussed in turn.

Organisational form

Economic activity will come to be conducted in a greater number of smaller firms, as demonstrated by both empirical evidence and theoretical reasoning (Brynjolfsson, et al1994, Langlois, 2003). Brynjjolfsson et al. argue that IT allows reduction in coordination costs with external counterparts, therefore making it progressively more likely, as IT develops, for activities to be organised between firms rather than inside firms. (The findings of this classic early study have been confirmed recently (Im et al, 2013)). Langlois (2003) argues that the large, vertically-integrated firm, co-ordinated by what

Alfred Chandler termed the ‘visible hand’ of management, has had its day. As various market-supporting institutions such as contracting processes, legal frameworks, standards, communications and IT develop, it becomes more feasible to co-ordinate specialised economic activity via market mechanisms, rather than within the firm. Hence, the "visible hand" of management *within* the firm is increasingly giving way to the "vanishing hand" of market-based coordination *between* many smaller, specialised organisations: ‘large, vertically integrated firms are becoming less significant and are joining a richer mix of organisational forms’ (ibid).

Data on UK manufacturing firms confirm this: in 1998, 71.6% of firms had fewer than 10 employees, and 4.1% had more than 100; in 2012, the proportion with fewer than 10 employees had risen to 74.4.%, and the proportion having more than 100 employees had fallen to 3.1%. At the very large end of the scale, in 2012 only 90 firms, 0.1% of the population, had more than 1000 employees: in 1998, the figure was 480 firms, or 0.3% 0f the population[11]. This isn’t an overnight revolution, but the data do confirm that the locus of activity is shifting toward the smaller and middle-sized firms. Medium-sized businesses are increasingly seen as both critical to future growth, and neglected, by commentators in both the UK and the USA. In the UK, the CBI argues that a focus on medium-sized businesses (50-500 employees, in their categorisation) is critical to UK manufacturing, as these constitute a far greater proportion in manufacturing (30%) than in the economy as a whole (15%)(CBI, 2011). In the USA, the US National Center for Manufacturing Sciences (NCMS) has coined the term ‘missing middle’, to refer to the neglected middle-sized firms that they argue are now the locus of employment and innovative activity. The proportion of all R&D investment made by middle-sized firms is growing: in 1983, it was 23%, in 2008, 64% (NCMS, 2011). The UK has a smaller proportion of large firms than several international competitor nations, notably the USA and Germany (EEF, 2011): that may mean that the UK is ahead of the field in adopting new forms, or could suggest a problem, given larger firms’ strong role in service innovation and supplier development.

Manufacturing firms in the UK are getting smaller partly because of increased productivity: UK manufacturing output per job almost tripled in the period 1979 to 2007 (PricewaterhouseCoopers, 2009). The same amount of production can be achieved by a smaller firm, largely because of automation. Additionally, the opportunities for outsourcing and offshoring lower-skilled work – and, indeed, some higher-skilled work, too (Manning et al., 2008, Learner and Storper, 2001) – mean that the scope of firms’ activities has changed as well. Furthermore, the NCMS points to the tendency for large OEMs to outsource more of their R&D and advanced design tasks to their middle-sized suppliers and partners. At the very small end of the firm spectrum, the ‘Maker’ movement (Anderson, 2012), using technologies such as small-scale additive manufacturing and internet-based sourcing of technical expertise, production capacity and distribution, means that firms with a handful of direct employees can nevertheless have the productivity of firms several times their size. Cloud-computing-based ‘software as a service’ means that very small businesses have access on a pay-as-you-go basis to the kinds of administrative support hitherto the preserve of larger firms.

These patterns suggest that, across the firm size spectrum, more and more value creation in manufacturing will take place at the interfaces between firms, through various forms of interaction, rather than through long sequences of processes inside the firm, insulated from the outside world. This is consistent with the discussion of value earlier in

[11] Source – ONS data

the report: multi-directional value constellations are a more accurate image than linear value-chains. Long-time scholars of organisation design, Miles and Snow (e.g. Miles et al, 1978) have recently linked organisational form to the business model concept:

"...we expect emerging organizational designs to be built, *first, on business models* that identify ways of creating and appropriating economic wealth by combining widely distributed knowledge and, increasingly, knowledge contained in communities of individuals and/or firms focused on a particular technology or subject. *Next, the corresponding organizational forms* will require ways to structure knowledge resources and manage them in order to more effectively benefit from the development of new products and services for a range of complementary markets. Such efforts will retain the useful features of existing firms and their organizational structures and processes while adding new capabilities designed to remove innovation barriers and offer new ways to leverage accumulating knowledge". (Miles et al, 2010, p97, emphasis added).

Miles et al's analysis puts the business model *first* and, to some extent, leaves the organisational form to work itself out. Furthermore, they argue that the dominant organisational form of the past two decades or so, the multi-firm network, coordinated by a lead firm, will give way to the new form they call the 'collaborative community'. Providing three contemporary examples, Miles et al argue that these approaches have three key ingredients: 'actors (individuals, firms, governments) who have collaborative capabilities and values, protocols and infrastructure that facilitate collaboration, and shared access to commons' (Miles et al, 2010:,p100). 'Commons' in this context means a shared body of knowledge and other resources.

This is resonant with the comments of one interviewee's view of one emerging technology area: what was important was to establish 'instruments' to allow, for example, SME start-ups to engage with larger ongoing research activities in a way and at a speed (quickly) that suited them. 'Instruments' here meant financial and institutional arrangements that allowed the collaboration to be effective and to everyone's advantage – in other words (those of Miles et al) 'protocols and infrastructure that facilitate collaboration'. It also echoes the view of another respondent that the role of design professionals will increasingly be designing systems of opportunities for collaborations to happen, rather than designing products or objects. The education and training of design professionals may need to be expanded to reflect this.

Interaction and indirect capabilities

The foregoing argument presents something of a paradox. On one hand, it suggests that market-supporting institutions and information technology make it easier to access all sorts of capabilities and resources through market mechanisms, rather than through direct control and management. On the other hand, even as the intimate linking through connections inside the boundaries of firms is replaced by market transactions, the ability to coordinate other types of activity through collaborative, interactive inter-organisational connections has never been greater. Furthermore, organisations and forms of organising will become more temporary (Mayloret al, 2006, Grabher, 2002). Even in more stable settings:

"Not only are firms with needs (problem holders) unaware of possible solutions in other parts of the economy, but firms that could offer help (solution holders) do not have enough information to be aware that they are in a position to be of use" (Robertson et al, 2009, p442) .

Consequently, the ability of firms to access others' capabilities will become absolutely critical. According to Hagel and Brown (2005), creating and capturing value will depend on having and developing specialised capabilities inside the organisation, combined with the ability to generate 'productive friction' with other organisations who specialise in complementary capabilities. Productive friction is 'capability-building by creating suitable settings for people with diverse and appropriate specializations to creatively resolve difficult business decisions' (Hagel and Brown, 2005, p22) – importantly, across multiple organisations. This will be counterposed with discriminating use of outsourcing for many, many intermediate goods and services as the progressive standardisation of offerings - from containerised shipping to engineering components, data storage solutions to subcontract labour (cf Amazon's 'Mechanical Turk') - takes effect (see also Spring et al, 2013).

3.2 Summary of themes for future manufacturing business models

The previous sections have outlined several widely varying themes that have emerged from the research. In summary, future business models will be shaped by the following themes:

- ownership will become more and more decoupled from use of products, and various forms of the circular economy will require the development of products, institutions and systems appropriate to recycling, re-manufacture and to more fluid attachments of products to owners and users
- many more facets of value will become important, including sustainability, personalisation, guarantees of provenance, and the information about these facets that become 'attached' to products
- information technology will enable these systems and products, and will enable further radical de-constructing and re-constructing of the activities involved in product manufacture (broadly defined), and in product use.
- value capture will, as ever, require a combination of strategic control of assets, and mechanisms for making transactions; however, the shifting terrain of ownership, use and re-use will create novel ownership scenarios, and new technologies, mostly linked to IT, will create myriad new ways to track, measure and remunerate.
- value will be created much more through the *interactions between* many small organisations, rather than through the *actions within* fewer, larger organisations

3.3 From emerging to future business models: the use of domains

It is not possible to predict or plan for specific business models in specific sectors, almost forty years into the future. It has been possible, however, to identify broader themes and current and emerging business models to some degree. There remains a need to confront the inherent difficulty of deciding what to do in the short-to-medium term about futures that are a long way off. We need to act now in relation to futures that are unknowable.

This study adopts a concept related to scenario planning, termed 'domains', derived from work by Rafael Ramírez and colleagues from Shell (Ramírez et al, 2011). Domains are used as an organising scheme for the substantive empirical and theoretical ideas that have resulted from the research. Domains are intermediate stabilisations of entities, which might include:

- Research on a particular problem area
- A group of loosely associated projects
- A group of people: hierarchical, horizontal, intra- or inter-organisational

(based on Ramírez et al, 2011: see original for fuller discussion)

Of particular interest to this present study is the claim that “domains’ primary ambition is to grow business value” (Ramírez et al, 2011, p261) – as opposed to being based on a particular technology, for example. For a firm such as Shell, domains are a way to capture individual technological innovations and turn them into actionable business activities that provide options for possible futures for the firm. For an economy such as that of the UK, domains might bring together technologies, firms, locales, special financial vehicles, etc., in order to provide options from which to engage with possible futures as they emerge.

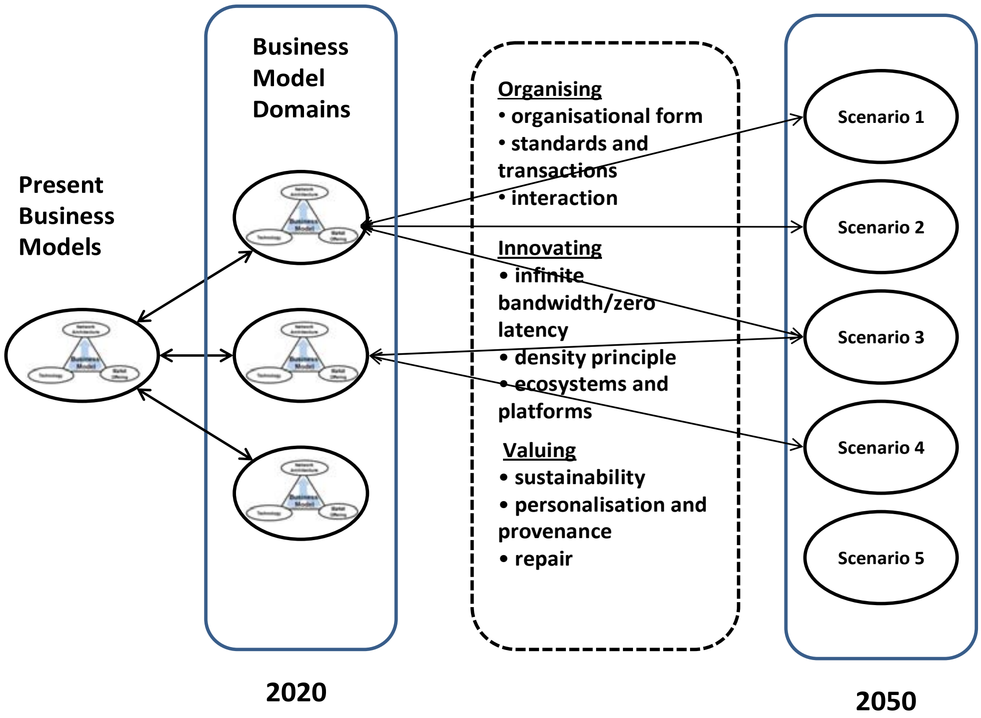
Domains are not just arbitrary stopping-off points on a route that is already planned, but active players in the organisation of activity in the immediate future. A compelling illustrative example of this role for domains is provided by Ramírez et al. (2011, p263).

“The domain also works as a mechanism to solicit ideas. Key learnings and assumptions become Ambitious Business Challenges like Kennedy’s “how can we put a man on the moon and bring him back to earth safely in 10 years time”. It is a holding place of ideas as well as of challenges that go to the root of the value creation potential of the domain. Overcoming the challenges produces a winning proposition. So projects/experiments focused on addressing the root causes/key challenges are prioritised.”

Domains could be seen as ‘work-outs’ for particular parts of the anatomy of UK manufacturing. We cannot know exactly what the final ‘event’ will be, but we can anticipate that developing some forms of ‘fitness’ will probably be useful. Furthermore, domains, like sports training programmes, can give shape, coherence and purpose to preparations that might otherwise be diffuse.

In this way, domains can be used as a basis for bringing together some of the themes identified in the research and interviews, and using them to shape concrete near-term policy initiatives. This is shown conceptually in Figure 3.2.

Figure 3.2 – Representation of the domains concept and its application



Scenario work in the wider project will identify possible futures (right-hand side of Figure 3.2). The themes discussed above will shape business model development, and are shown in the space between 2020 and 2050 (although they are already in play now). On the left-hand side of the figure, the current state of business models – offerings, networks and technologies – is represented by the small Business Model Framework 'triangle'. The triangles at 2020 (three are shown for illustrative purposes, but there will be more) suggest various domain-based initiatives that would concentrate on particular aspects of the whole. Some might be oriented toward particular emerging technologies, others toward particular areas of need, yet others toward certain of the themes identified. (The Technology Strategy Board's 'Catapult Centres' have many of the features of 'domains', although many are, reasonably enough, rooted in particular general-purpose technologies rather than being oriented toward business model issues.)

With this logic in mind, the report now turns to more specific questions about future business models.

3.4 Sectors, technologies and business models

What does this mean for current value chains in specific sectors – and future supply chain optimisation (greater splintering / more dynamic)?

Can businesses be designed and positioned to capture significant elements of value added in the UK?

Which areas of technology will be most significant in supporting business model innovation and emerging sectors (including digital technology, robotics / automation, nanotechnology, additive layer manufacturing, distributed and personalised green technology)?

The need to cut across established sectors has already been stressed. Indeed, the research revealed a wide range of understandings and usages of the idea of 'sector'. In some instances, sectors are associated with particular emerging technologies e.g. industrial biotechnology (NESTA, 2011). At the other extreme, sectors are associated with particular end uses, e.g. the energy sector, which might use biotechnology-derived inputs. The framing of an area of activity depends on the reason for such framing: for some purposes, treating biotechnology as a sector is helpful, because it may have special needs in terms of, for example, its financing in the relatively early stages (NESTA, 2011). Later in the development of an emerging technology, however, such treatments cease to make much sense.

What does this mean for current 'sectors'? As discussed, the long-term trajectory of organisational form is to move away from large, vertically integrated, self-sufficient firms with large commitments – in the form of capital equipment, especially – to particular, stable, vertical sectors. If the future organisational form is, indeed, something resembling 'collaborative communities', rather than tightly-coupled networks dominated by a few lead firms, then fragmentation will be increased across many existing sectors. The ability to digitise and 'unbundle' established roles and processes (see 'Density principle', above) will only add to this tendency. However, this doesn't mean that all links between activities can be plugged, unplugged and relocated at will. A US National Research Council study on emerging technologies (Macher and Mowery, 2008) stresses the need for some stages in the translation of emerging technologies into specific product- or service-markets to be co-located. In semiconductors, for example, while advanced design is still carried out in the US, development and production of specific embodiments in specific products for specific customers immediately takes place overseas – in this instance in Taiwan, because of the need to be near the demanding intermediate customers that are the producers of e.g. notebook computers and, now, tablets. This is echoed in broader-based contemporary UK analyses e.g. by the EEF, and in recent empirical research (Spring and Araujo, 2013) on the vital importance of co-location of product development and production 'itself'. Translating this illustrative insight to the UK means that, given the tendency of UK firms to carry out production in the UK, or to offshore production primarily for cost reasons (EEF, 2009), there may in some cases need to be a step change in small and medium-sized firms' capability and readiness to set up design and development facilities close to overseas customers.

Domains potentially offer a way of conceptualising, shaping and accelerating the fusing together of sectors and generating the 'productive friction' that gives rise to new solutions and new business models. For example, the IBZL research anticipates the development of '"always on" social space' which it links in principle to the need for the aging population to be able to live independently (Bell and Walker, 2011). A domain, then, might take the form of a collection of interested organisations – social care bodies, manufacturers and installers of equipment, providers of accommodation, elderly users, their relatives and so on – developing the three elements of the business model in a sustained experiment, perhaps in a particular locale with a high density of elderly people. Business model innovation is often a trial-and-error process, and it is unlikely that any one of these actors could mobilise the network on a speculative basis: this is where policy interventions would be needed. The other important part of the process is to capture the learning about capabilities and to transfer them to other relevant areas of application.

4. Future manufacturing business models: opportunities, constraints and policy

What do business model innovators see as the key emerging value opportunities?

What are the opportunities for British Industry if they adopt new business models?

What constraints/barriers are to be overcome if such business models are implemented?

The over-arching task of the policies arising from this study is to bring about the connection between emerging sectors and the business models that will ensure value for the UK. Here, emerging sectors are taken to mean both emerging general-purpose technologies such as biotechnology, and emerging areas of social practice such as, say, support for the independently-living elderly. The earlier sections have discussed themes that will shape this task. Accepting that it is impossible to identify specific business models for specific sectors in 2050, it is nevertheless possible to identify what forms of development of UK manufacturing are likely to be useful in preparation for those futures and to stake out some routes for immediate action. Domains may present a useful vehicle within which to structure these efforts.

Based on the foregoing discussions, it is proposed that future manufacturing business models will be characterised as a number of connections. This is not simply to repeat the oft-stated fact that firms are connected to one another in networks. Rather, it is to use connectedness as a pervasive theme in the business models that manufacturing must develop to prepare itself for what lies ahead.

Connect products to services, extensively, and in 'upstream' sectors as well as in complex product sectors

Opportunity: Services will be important ways to create extra value and avoid commoditization. They will also become an intrinsic part of a manufacturing that exists within more circular, interactive ecosystems where value is created between rather than predominantly within firms. Services must be embraced extensively, and be intimately connected to the products with which they are associated, in order to create value. Different forms of service entail different business models.

Barrier: Managers in manufacturing firms often find organisational, conceptual and institutional obstacles to bringing about these bold moves into services.

Connect technologies to potential future application areas and needs, widely drawn

Opportunity: General-purpose technologies (GPTs) must be connected to new and growing areas of use, not just inserted as replacement materials in already-existing product forms. Multiple GPTs, combined with IT, should be explored in combination in broad areas of use.

Barrier: Technology providers and potential users – 'problem-holders' – may be unaware of their mutual value-creation opportunities.

Connect products to information, institutions and individuals, to create value

Opportunity: Products that are connected to information about their provenance, circumstances of production and history of use, repair and re-use, will have an increasing premium value. This may be associated with particular validating institutions. Personalisation of products through the use of information as well as by physical form and associated services will also have enhanced value.

Barrier: concerns about data property rights and privacy

Connect – and disconnect, as necessary – firms to one another in collaborative communities

Opportunity: A key capability for manufacturing firms will be to connect to and disconnect from network counterparts who provide complementary resources and capabilities. In this sense, indirect capabilities – the ability to connect with other firms and access their capabilities – will be as important as the direct capabilities a firm has to play its own part particularly well.

Barrier: Locating, understanding and accessing other's technology requires both relational and information technology capabilities and requires managers to think outside their familiar sectors and supply chains.

Connect the forward and reverse flows of products in a circular economy

Opportunity: Repair, re-manufacture and other aspects of the circular economy will become normal, and yet require technological, organisational and institutional change of a profound nature to reconcile the traditional linear, forward flow with the growing circular flow. This requires systemic change.

Barrier: Many technological, organisational, accounting and other institutional contexts in which manufacturing takes place are predicated on a linear, forward-flowing supply chain.

Connect technological and operational capabilities with entrepreneurial insight and action

Opportunity: There is an increasing need for individuals who combine a technological grasp of their own firm's potential, with insight into how new productive opportunities can be created with network counterparts. This is different to established forms of 'technical sales', and is a role and skill-set that is in short supply.

Barrier: Although technological innovation is formalised in departments, roles, education and training, business model innovation is not – in short, whose job is it, and what skills are needed.

Connect firms' business models to one another

Opportunity: Firms cannot innovate their business models in isolation – almost by definition, a change in one firm's business model must be accompanied by changes in its counterparts' business models.

Barrier: As well as a deficiency in the skills and abilities to identify and design business model innovation, there is also a lack of tools, language and frameworks with which to articulate business model innovation across firm, sector and technology boundaries.

Policy implications

Domains, perhaps taking the form of ‘Business Model Catapults’, are proposed as one vehicle for making these connections happen. These could take various forms. They all depend on bringing together disparate resources and actors that otherwise would not come together, and in some ways removing obstacles that present difficulties, rather in the way that IBZL ‘imagines away’ any limitations of the internet. Allowing these to be self-selecting in, say, competitions for funding, may serve to reinforce existing sectoral and technological cliques and fail to create ‘productive friction’, so alternative incentives and mechanisms for participation may be needed.

Domains could be based on locales, such as particular cities or towns (it has recently been observed by the Secretary of State that there remains huge regional disparity in the economic impact of the financial crisis). One possible focus for such a domain is the development of circular economy and collaborative consumption infrastructures in relation to selected business-to-business and business-to-consumer products.

Several of the opportunities for connections relate to managerial abilities and predispositions. There is a need to identify and nurture a breed of ‘entrepreneurial manufacturing network heroes’: managers with technological know-how who can also see and develop opportunities for connections between firms and for business model development. Medium-sized businesses may be the sources of such individuals, since these businesses have some flexibility in organisational resources and are increasingly the site of technological and organisational innovation previously the preserve of larger firms.

As has been evident throughout the report, there are no standards datasets on business models as such. They are very difficult to define and measure in any meaningful way, but the development of some kind of reference indicators would be very useful. The Community Innovation Survey (CIS) has been enhanced to take account of service innovation and ‘wider’ innovation, and it may provide an initial platform for additional data-collection on business models. Other European countries (e.g. Germany, Sweden, Finland) are active in studying and developing alternative approaches to manufacturing, so a pan-European approach to such a data-collection effort would be in the interests of a number of participants in the CIS.

References

Amit, R. and Zott, C. (2001) Value creation in e-business, *Strategic Management Journal,* 22493-520.

Anderson, C. (2012) Makers: the new industrial revolution. London, Random House Business Books,

Anderson, J. C.and Narus, J. A. (1995) Capturing the value of supplementary services, *Harvard Business Review,* 73(1)**,** 75-83.

Anon (2010) SKF documents $2 billion in customer savings. Reliable Plant.(note that there should be a better reference than this - from the SKF website if nothing else)

Araujo, L., Mason, K. J. and Spring, M. (2012) Self-driving cars - a case study in making new markets. London, The Big Innovation Centre.

Baldwin, C. Y. (2008) Where do transactions come from? Modularity, transactions, and the boundaries of firms, *Industrial and Corporate Change,* 17(1)**,** 155-195.

Bell, S. and Walker, S. (2011) Futurescaping Infinite Bandwidth, Zero Latency, *Futures,* 43(5)**,** 525-539.

BIS (2010a) Manufacturing in the UK: an economic analysis of the sector. *BIS Economics Papers.* Department for Business, Innovation and Skills.

BIS (2010b) Technology and innovation futures: UK growth opportunities for the 2020s. Department for Business, Innovation and Skills, Foresight, Government Office for Science.

BIS (2010c) UK Innovation Survey 2009: Science and innovation analysis. Department of Business, Innovation and Skills.

Björkdahl, J. (2009) Technology cross-fertilization and the business model: The case of integrating ICTs in mechanical engineering products, *Research Policy,* 38(9)**,** 1468-1477.

Brynjolfsson, E., Malone, T. W., Gurbaxani, V. and Kambil, A. (1994) Does Information Technology Lead to Smaller Firms?, *Management Science,* 40(12)**,** 1628-1644.

CBI (2011) Future champions: unlocking growth in the UK's medium-sized businesses. London, Confederation of British Industry.

Chesbrough, Hand Rosenbloom, R. (2002) The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies, *Industrial and Corporate Change,* 11(3)**,** 529-555.

Cusumano, M. (2010) *Staying power: Six enduring principles for managing strategy and innovation in an uncertain world,* Oxford, Oxford University Press.

Duguid, P. (2010) Brands in chains. In Lopez, T. D. S. & Duguid, P. (Eds.) *Trademarks, brands and competitiveness.* New York, NY, Routledge, 138-164

EEF (2009) Manufacturing advantage: How manufacturers are focusing strategically in an uncertain world. London, Engineering Employers' Federation.

EEF (2011) The shape of British Industry: growing from strong foundations. London, Engineering Employers' Federation.

Fang, E., Palmatier, R. W.and Steenkamp, J.-B. E. M. (2008) Effect of Service Transition Strategies on Firm Value, *Journal of Marketing,* 72(5)**,** 1-14.

Gadrey, J. (2000) The characterisation of goods and services: an alternative approach, *Review of Income and Wealth,* 46(3)**,** 369-387.

Giesen, E., Bergman, S., Bell, R.and Blitz, A. (2007) Paths to Success: Three Ways to Innovate Your Business Model. IBM Global Business Services - IBM Institute for Business Value

Golicic, S. L.and Smith, C. D. (2013) A Meta-Analysis of Environmentally Sustainable Supply Chain Management Practices and Firm Performance, *Journal of Supply Chain Management,* 49(2)**,** TBA.

Grabher, G. (2002) Cool Projects, Boring Institutions: Temporary Collaboration in Social Context, *Regional Studies,* 36(3)**,** 205-214.

Graham, S. and Thrift, N. (2007) Out of order: understanding repair and maintenance, *Theory, Culture & Society,* 24(3)**,** 1-25.

Hagel, J. & Brown, J. S. (2005) *The only sustainable edge : why business strategy depends on productive friction and dynamic specialization,* Boston, Mass., Harvard Business School Press.

Im, K. S., Grover, V. and Teng, J. T. C. (2013) Research Note - Do Large Firms Become Smaller by Using Information Technology?, *Information Systems Research,* TBA.

IPO (2011) An analysis of worldwide patent filings relating to graphene. UK Patent Office.

Jacobides, M., Knudsen, T. and Augier, M. (2006a) "Who does what" and "who gets what": capturing value from innovation. London, Advanced Institute of Management Research.

Jacobides, M. G., Knudsen, T. and Augier, M. (2006b) Benefiting from innovation: Value creation, value appropriation and the role of industry architectures, *Research Policy,* 35(8)**,** 1200-1221.

Kortuem, G., Kawsar, F., Fitton, D. and Sundramoorthy, V. (2010) Smart objects as building blocks for the Internet of things, *Internet Computing, IEEE,* 1444-51.

Langlois, R. N. (2003) The vanishing hand: the changing dynamics of industrial capitalism, *Industrial and Corporate Change,* 12(2)**,** 351-385.

Langlois, R. N. and Cosgel, M. M. (1998) The organization of consumption. In Bianchi, M. (Ed.) *The active consumer : novelty and surprise in consumer choice.* London ; New York, Routledge, 107-121

Lay, G., Copani, G., Jäger, A. and Biege, S. (2010) The relevance of service in European manufacturing industries, *Journal of Service Management,* 21715-726.

Learner, E. E. and Storper, M. (2001) The economic geography of the internet age, *Journal of International Business Studies,* 32(4)**,** 641-665.

Macher, J. T. and Mowery, D. C. (Eds.) (2008) *Innovation in Global Industries: U.S. Firms Competing in a New World (Collected Studies),* Washington D.C., The National Academies Press.

Malone, T. W., Weill, P., Lai, R. K., D'urso, V. T., Herman, G., Apel, T. G. and Woerner, S. L. (2006) Do some business models perform better than others? Cambridge MA, MIT Sloan School of Management.

Manning, S., Massini, S. and Lewin, A. Y. (2008) A Dynamic Perspective on Next-Generation Offshoring: The Global Sourcing of Science and Engineering Talent, *Academy of Management Perspectives,* 22(3)**,** 35-54.

Mason, K. and Spring, M. (2011) The sites and practices of business models, *Industrial Marketing Management,* 40(6), 1032-1041.

Maylor, H., Brady, T., Cooke-Davies, T. and Hodgson, D. (2006) From projectification to programmification, *International Journal of Project Management,* 24(8), 663-674.

McGovern, T. (2007) Why do successful companies fail?: a case study of the decline of Dunlop, *Business History,* 49(6), 886-907.

Miles, R. E., Snow, C. C., Fjeldstad, Ø. D., Miles, G. and Lettl, C. (2010) Designing Organizations to Meet 21st-Century Opportunities and Challenges, *Organizational Dynamics,* 39(2), 93-103.

Miles, R. E., Snow, C. C., Meyer, A. D. and Coleman, H. J., Jr. (1978) Organizational Strategy, Structure, and Process, *The Academy of Management Review,* 3(3), 546-562.

Mont, O. (2004) Institutionalisation of sustainable consumption patterns based on shared use, *Ecological Economics,* 50(1-2), 135-153.

Mulgan, G. (2013) *The locust and the bee: predators and creators in capitalism's future,* Princeton NJ, Princeton University Press.

NCMS (2011) The invisible innovators: what is the missing middle? and why do we need them? , NCMS.

Neely, A. (2008) Exploring the financial consequences of the servitization of manufacturing *Operations Management Research,* 1(2), 103-118.

Neely, A., Benedetinni, O. and Visnjic, I. (2011) The servitization of manufacturing: Further evidence. *18th European Operations Management Association Conference.* Cambridge, UK.

NESTA (2011) Financing industrial biotechnology in the UK. National Endowment for Science, Technology and the Arts.

Normann, R. (2001) *Reframing business: when the map changes the landscape,* Chichester, John Wiley.

Normann, R. and Ramirez, R. (1993) From Value Chain to Value Constellation - Designing Interactive Strategy, *Harvard Business Review,* 71(4), 65-77.

Novoselov, K. S., Falko, V. I., Colombo, L., Gellert, P. R., Schwab, M. G. and Kim, K. (2012) A roadmap for graphene, *Nature,* 490(7419), 192-200.

OECD (2007) Staying competitive in the global economy: moving up the value chain. OECD Publishing.

Pavitt, K. (2003) Specialization and systems integration: where manufacture and services still meet. In Davies, A., Hobday, M. & Prencipe, A. (Eds.) *The business of systems integration.* Oxford, Oxford University Press, 78-91

PricewaterhouseCoopers (2009) The future of UK manufacturing: reports of its death are greatly exaggerated. PricewaterhouseCoopers.

RAEng (2012) Industrial systems: capturing value through manufacturing. London, The Royal Academy of Engineering.

Ramirez, R. (1999) Value co-production: Intellectual origins and implications for practice and research, *Strategic Management Journal,* 20(1), 49-65.

Ramírez, R., Roodhart, L. and Manders, W. (2011) How Shell's Domains Link Innovation and Strategy, *Long Range Planning,* 44(4), 250-270.

Robertson, P., Smith, K.and Von Tunzelmann, N. (2009) Innovation in low- and medium-technology industries, *Research Policy,* 38(3)**,** 441-446.

Sissons, A. and Thompson, S. (2012) Three dimensional policy: why Britain needs a policy framework for 3D printing. London, The Big Innovation Centre.

Spring, M. and Araujo, L. (2013) Beyond the service factory: service entrepreneurship in manufacturing supply networks, *Industrial Marketing Management,* 42(1)**,** 59-70.

Stahel, W. and Reday, G. (1976/1981) Jobs for Tomorrow: The Potential for Substituting Manpower for Energy. Brussels/ Vantage Press, New York Commission of the European Communities.

Suarez, F. F., Cusumano, M. A. and Kahl, S. J. (2013) Services and the Business Models of Product Firms: An Empirical Analysis of the Software Industry, *Management Science,* 59(2)**,** 420-435.

Teece, D. J. (1986) Profiting from technological innovation: implications for integration, collaboration, licensing and public policy, *Research Policy,* 15(6)**,** 285-305.

Teece, D. J. (2010) Business Models, Business Strategy and Innovation, *Long Range Planning,* 43(2–3)**,** 172-194.

Zott, C. and Amit, R. (2007) Business model design and the performance of entrepreneurial firms, *Organization Science,* 18(2)**,** 181-199.

Zott, C. and Amit, R. (2008) The fit between product market strategy and business model: implications for firm performance, *Strategic Management Journal,* 29(1)**,** 1-26.

Zuboff, S. (1988) *In the age of the smart machine: the future of work and power,* New York, Basic Books.

Appendix

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