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Executive Summary

Over the last century the United Kingdom has seen a steady transition from a predominantly manufacturing-based economy to a predominantly service-based economy. Within the context of manufacturing, the two key dimensions for this transformation are the extent of a focus on ‘outcomes’ rather than through ownership of goods and the extent of personalisation of manufactured goods to meet users’ needs. Together these represent the twin challenges of service design and customisation.

The opportunities and challenges of service design and customisation are being driven by the utilisation of new technologies including Artificial Intelligence (AI), robotics, autonomous systems, large scale data analysis, Internet of Things (IoT) and myriad other technologies supported by a hugely increased use of captured data to support decision making.

In order to better understand how and why this transformation is occurring, and where it will lead, we need to grasp an understanding of these technologies, the business models that underpin them, and the societal challenges that drives the development of manufacturing in the industrialised world. The German concept of Industry 4.0 is a useful framework against which to review the present state (Henning, Wolfgang and Johannes, 2013). There are three key components which are: the Internet of Things; Cyber-Physical Systems (CPS); and Smart Factories. However, it is important to point out that these three components are a very ‘factory-centric’ view, significantly underplaying the role and importance, of the customer.

The increased use of digital technologies has also enabled the rapid growth of social media and personal data. This in turn has supported the transition from marketing as a one-way communication channel to an increased awareness of the benefits of a rich bi-directional communication system. Digital technologies and customer-centric decision-making all contribute to a move from value being embedded in manufactured goods alone, to a deeper understanding that value is clearly recognised by consumer and manufacturer at the point of use. Acquiring and processing customer use data is achieved through a much deeper, formalised and integrated range of digital services than those that existed for previous generations of manufacturing systems. This integration of services into manufacturing systems is referred to as servitization, the “process of building revenue streams for manufacturers from services.” (Baines et al., 2017).

This application of Digital Technologies through service design and customisation offer a huge potential to impact productivity, growth and commercial resilience. An exploratory project across 77 SMEs in the West Midlands has recently demonstrated that early adoption of these ideas can stimulate growth in Gross Value Added (GVA) of £7,500/employee and productivity improvements by 16%\(^a\). While some businesses in the UK will realise these opportunities through new value creation and capture, others will lose out as competitors, exploiting the potential for digital technologies, move into and disrupt their value networks. The national need is therefore to rapidly accelerate the innovation of these digitally enhanced service offerings throughout the UK.

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\(^a\) Exploiting Servitization in West Midlands SMEs; Project 080/016/P2, ERDF-funded Business Support Project; (2012-2015)
1. Background

Over the last century the United Kingdom has seen a steady transition from a predominantly manufacturing-based economy to a predominantly service-based economy. Whilst consumers want ‘solutions or outcomes’ they need products to be manufactured to enable the provision of the service. Additionally, manufacturing plays an important role in wealth creation, both in terms of the value of the goods created, but also as goods that can be exported. As we move forward from an industrial model based on the ideas of the earlier Industrial Revolutions, with their focus on products leaving the factory gates, so we now focus more on the way in which products are used. This is a shift from the object being created and sold to the processes of use (Vargo and Lusch, 2004).

The increasing integration of the Internet of Everything into the industrialised manufacturing value chain has built the foundation for the next industrial revolution: Industrie 4.0 [Industry 4.0 henceforth]. This “involves fast and disruptive changes that embrace digital manufacturing, network communication, computer and automation technologies” (Pereira and Romero, 2017) and “the main role of humans shifts from an operator of machines towards a strategic decision-maker and a flexible problem solver.” (Hermann, Pentek and Otto, 2016). The term Industry 4.0 underlines the integration of the Internet of Things and Services (IoTS) into manufacturing as well as internet-based communication of objects (Kiel, Arnold and Voigt, 2017). The Smart Factory is essentially the embodiment of the philosophy of Industry 4.0 and is “focused on creating smart products, procedures and processes…capable of managing complexity [and a place where] human beings, machines and re-sources communicate with each other as naturally as in a social network.” (Henning, Wolfgang and Johannes, 2013).

The Smart Factory model, encapsulated in Industry 4.0, emerged from the confluence of new technologies, data science, and Artificial Intelligence which itself enables traditionally separate manufacturing functions such as Operations, Design and Logistics to be integrated with Marketing and Sales. There has been a transition from a clear split between services and products, to a complex model whereby products are as much defined by the services around them that describe the design, production and use of the otherwise tangible item.

Dick Elsy, (CEO of the High Value Manufacturing Catapult (2016) describes this service-oriented life-cycle approach as: “Through Life Engineering, the concept of not just the manufactured product but an entire service. Rolls-Royce invented the concept of ‘power-by-the-Hour’ in 1962 with a complete engine and accessory replacement service offered on a fixed-cost-per-flying-hour basis. This therefore aligned the interests of the manufacturer and operator who only paid for fault-free engines (Rolls-Royce, 2012). Another aviation example can be found at Schiphol Airport, Amsterdam, which has contracted Philips to provide lighting as a Service (Duffhues, 2016). Nicklin Transit Packaging based in Birmingham, UK, have utilised the benefits of IoT and other technologies to deliver packaging as a service with the conclusion that: “the manufacturer takes on more risk when competing through services because they are guaranteeing an outcome, and if the outcome isn’t delivered, it’s [the manufacturer’s] responsibility.” (Thompson, 2017).

This model has been achieved by: “a shift from the supplier perspective - and the means of production – to a customer perspective and a focus on utilization.” (Gummesson, 1991). In other words, we are seeing a move to value being created through use, with the consumer deeply embedded in the creation of value. The reason for this is that the traditional model for manufacturing whereby raw materials are fed in, and tangible goods are sold for profit is rapidly disappearing through a combination of diminished margins and emerging markets with lower costs. As a result, “products can become commoditized and suffer from increased pricing pressure.” (Fernando et al., 2014). This erosion of profit margins has led to the rise of “servitization – the process of moving towards a product-service system.” (Macdonald, Martinez and Wilson, 2009).
2. Types of business model

A rich framework (Noventum 2017) for understanding the change in business models is presented by the Aston University’s Advanced Services Group (ASG) which breaks down the elements of how these concepts can be implemented (see Figure 1). They identify four main types of customer ‘offering’.

Figure 1: ASGs 4 ways to use IoT

1. Availability Services: here ‘uptime’ is guaranteed and payment is made based on availability. The challenge is how to reduce the additional product risk that the manufacturer has agreed to manage; the contract is often a balance of risk and reward across the partners.

2. Process Optimisation: manufacturers provide equipment into a process and through this provide advice on how best to optimise the process. Analysing the data from the equipment is central to this offering.

3. Business Optimisation: extends the process optimisation across the whole business and supply chains, and provides a long-term capability. A good example here is ‘power by the hour’, providing a service that is key to airlines.

4. Business Transformation: this is where the manufacturer takes the opportunity from IoT to provide new business opportunities for their customers. Often these are based around the provision of a platform, and the service focus moves from the physical to the digital data.

In a similar vein, but from a more customer oriented perspective, Smith et al., (2012) identify four distinct value propositions for the customer: “asset value proposition; recovery value proposition; availability value proposition; outcome value proposition. The latter, outcome-based value proposition is the ultimate goal of this transition where “the customer purchases “utility” as an outcome instead of the “function” of the product” (Smith et al., 2012).

However, in many instances, organisations will be looking to deliver a combination of these value propositions through a complex matrix of systems-level management methods.

How do we achieve this in practice? This is an iterative, multi-disciplinary and collaborative process to create and deliver value to customers, which has in turn resulted in financial and environmental benefits when firms “change their business models and customers revise their conceptions of ownership.” (Neely, 2009). This transformational change is hard to do. The particular challenge for digitalisation as a means to achieving servitization, is that all departments will be affected, both in terms of the internal activities, and also their relationships with each other. Traditionally, manufacturing companies have seen their essential role as adding
value to raw materials by turning them into tangible goods. Internal processes are typically focused on different aspects of adding elements of value to the processed materials. The servitized manufacturer seeks to allow value to be created at the point of use. Hence the digitalised transformation of the organisation is now focused on capturing and understanding the customers’ role in the value creation process, and feeding this information back up the supply chain to inform the constituent processes both within the factory and supply chain.

3. Manufacturing for the future

Implementation of the distributed supply chain: B2B meets B2C

The increased granularity of data and processes enables value-creation to be delivered to customers by networks of collaborating firms, integrating the products and services they offer to mutual benefit. In practice, this is typically seen in a distributed supply chain, a sequence of business-to-business (B2B) transactions culminating in business-to-consumer (B2C) relationship. In other words: “value can be most effectively delivered by networks of collaborating firms, integrating the products and services they offer to create the value which customers seek. In short, creating value requires the simultaneous design of product, service and organisation – the PSO triangle” (Pawar, Beltagui and Riedel, 2009). Businesses that exhibit these characteristics are evolving into an ecosystem of collaborating and competing organisations.

Whilst all of the organisations in the supply chain can benefit from becoming Product Service Organisations (PSO) delivering Product Service Systems (PSS), “experiential services” are a more suitable form of PSS for consumer markets, but “solutions” are generally more applicable for industrial markets.” (Pawar et al., 2009). The key point being that the customer, as co-creator, has to be dominant in feeding data up the supply chain. This could even be considered a Me-2-B model where firms are “collaborating with and learning from customers and being adaptive to their individual and dynamic needs.” (Vargo and Lusch, 2004). There is an added benefit to adding value-creating downstream services to distributed product supply chains: “the higher margins and the need for fewer assets typically provides steady, service-related revenue streams that can ride economic turbulence. (Fernando et al., 2014).

This Me-2 B model is being enabled by digital technologies such as IoT in the home and personal data. In the traditional linear model, the line of visibility (Holmström, Brax and Alarisku, 2010) ends at the retail store and Point of Sale (PoS) data is used as an indicator of purchasing demand. There is only a very limited understanding, usually from surveys, of consumer use and involvement in post-consumption practices of use, recycling, disposal etc. (O’Cass and Ngo, 2011). Extensive research has shown that as Supply Chain Visibility increases, so does firm performance (Kulp, 2002) through improved inventory management and better understanding of demand (Kaipia and Hartila, 2006). For example, Gavirneni et al. (1999) reported a 35% cost reduction and Lee (2000) found inventory reduction of up to 40%. Through engaging the user, we can understand more about use of both appliances and commodities. This has a number of potential benefits, for example:

1. Condition monitoring of an appliance can be used to influence user behaviour to improve the lifetime of the asset. For example, according to the charity Wastewatch, 2.4 million fridges and freezers are thrown away every year in the UK, many of which are for very basic problems e.g. motors or door seals (Wastewatch 2004). This may result in emerging business models based on pay per use or the invigoration of local repair businesses.

2. Feedback can help affect consumption of commodities e.g. major international studies estimate that 50% of all food is wasted (WRAP
2009) and 30% of clothing has not been worn for at least a year (WRAP 2012).

3. Information on the appliance and the commodity enables the development of more effective and efficient forward supply chains both for the manufacturer and logistics firms that can better optimise transport flows and fleet purchases.

4. Data on use provide valuable insights for design of future generations of products and the related business models.

5. User engagement has the potential to transform the restorative cycle, particularly maintenance, through information on appliance performance. For repair businesses, data on how, where and by whom the product was used will help decisions on facility location, diagnostic processes and process layout.

6. Help with safety aspects. IFSEC Global (2016) found that faulty appliances are the cause of 3700 domestic fires a year.

4. Variety and service design

One of the consequences of a greater focus on the customer and use is the challenge of managing increased variety. The stochastic nature of customer-supplied inputs means that the transition from product to service has radical implications for service design, where operations need to be “capable of dealing with random arrivals, inconsistent specifications, and varying input quality.” (Sampson, 2004).

The Customer Order Decoupling Point (CODP) reflects the productivity-flexibility trade-off, which separates decisions made under certainty from decisions made under uncertainty (Olhager, Wikner and Rudberg, 2001). This is often referred to as postponement that is differentiating the customisation of a product, for example in its form or place, until the last possible point (Feitzinger and Lee, 1996). The key to postponement lies at the point where the demand signal enters the supply chain and where work-in progress gets turned into specific end products (Forza, Salvador and Trentin, 2008).

The positioning of the CODP balances the needs of the customer and the provider. The further the CODP is positioned downstream the greater the emphasis is placed on productivity and more processes can be designed to achieve economies of scale. Alternatively, by placing the CODP further upstream a company can achieve greater flexibility and customers have a greater input. However, this greater variety impacts on the scale economies of specialisation of machinery, labour flexibility and knowledge, risk pooling of inventory, challenges of inventory obsolescence, etc.

The key to overcoming the productivity / personalisation trade-off is having access to the earlier information that signals the forming of the need in the demand chain allows the provider side to orchestrate their supply chain in sync with the evolving customer needs. Thus, the provider can gain cost and time savings by reducing slack and bullwhip effects, and improve quality based on more accurate tailoring of their offering against a specific use-context (Holmström et al., 2010).

Whilst there are examples of integrated solutions in B2B environments (e.g. ‘power by the hour’) fundamentally, any further practical implementation in B2C depends on the development of technical platforms that could capture data on consumption or use within the consumer’s context. The end result of this focus on the flow of information back up the supply chain is an enhanced involvement of the end user in the development of the supply chain whether distributed or contained within a single manufacturing entity. There is a potential for considerable research into how further understanding of use can help service design and customisation.

5. Conclusions

The digital economy is an enabler of the smart factory ecosystem. Service, utility and timeliness are now taken for granted and the discernible value in the digital economy is not in the data so much as the ability of the data to create value. We have argued in this report that whilst Artificial Intelligence, Machine Learning and robotics are essential components of future manufacturing, the firm alone cannot ‘satisfy’ a customer; they can only collaborate with the customer in supporting value co-creation. For many manufacturing firms this means a movement from a focus on output and product to one of outcome and use: this movement is termed servitization.
Industrialised manufacturing is beginning to provide the potential for extensive customisation at scale. The transition towards servitization represents an evolution from consumers simply purchasing goods to a more extensive engagement. As a result of these demands for personalisation and customisation, and also the availability of new manufacturing technologies such as 3-D printing, we are now in a state where: “the interaction behaviour of consumers as designers in the enterprise production has become more common.” (Tao, Cheng, Zhang and Nee, 2017).

“The most significant challenge facing both researchers and practitioners of servitization is how to efficiently and effectively transform a manufacturing organisation to exploit this opportunity.” (Baines et al., 2017). There are great challenges for services, utilities and integrated distributed supply chains requiring bi-directional communication through the supply chain as well as within the firm, and most importantly, with the customer. However, there are tremendous opportunities not just for productivity but also for the circular economy and related ideas to support the green agenda for a healthier planet.

6. Recommendations

The following recommendations have emerged from this research; recommendations that can inform practitioners and academics alike:

Specific immediate opportunities exist for:

1. Developing incubator labs where researchers can explore personal data and its impact on firm/supply chain productivity.

2. Developing simulation models of supply chains looking at scale opportunities for integrated logistics and the circular economy.

3. Developing use cases, models and frameworks to identify strategies for dealing with increased variety.

4. Exploring the opportunity for services amongst SMEs. How can SMEs innovate and exploit a digital platform strategy that provides them with the collective design authority and production capability to win, and support, large service contracts in partnership with multinational manufacturers?

Longer term research is needed in:

1. The development of a major research programme looking at how factories and supply chains manage, long term, in high variety environments e.g. managing technology and skills and competencies so that productivity increases.

The transformational journey towards a more service-focused organisation requires organisational restructuring around people. Therefore, the workforce, in order to be able to collaborate both in teams and across traditional silos, will need strong collaboration and communication skills in addition to deep specialist skills covering a raft of new and future technologies. This ability to combine deep specialist knowledge in a particular area, with a broad range of common team and leadership skills is often referred to as a T-shaped profile (Demirkan and Spohrer 2015). Frameworks such as EDISON⁶ exist to help analyse and identify needed skills and competences, but teams and leaders will henceforth require lifelong learning approaches to thrive in the industrialised manufacturing world of the future. These needs are further articulated in the Government-funded independent report on AI: “Government, industry and academia must embrace the value and importance of a diverse workforce for AI, and should work together to break down stereotypes and broaden participation.” (Hall and Pesenti, 2017).

2. The longer-term threat that manufacturing will become a public good (i.e. free) and that the data provided by the object/device is more valuable than the object itself. Manufacturers then have to move not just into service but beyond that into ‘data’ managers and the competitors in that space are already well established (e.g. Google, Amazon, Accenture etc.).

⁶ http://edison-project.eu/
7. References


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