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Manufacturing best practice and UK productivity

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Manufacturing best practice and UK productivity

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Executive summary

Companies with best practice generally perform better than others. To be effective across a whole business, best practice activity needs to be appropriate for the business and deliver a competitive advantage. The efficiency of a company relative to others determines its market share. Finding, adapting and implementing best practice can deliver significant competitive advantage and lead to increased market share.

Within the UK, best practice is most evident within automotive and aerospace companies, followed by plastics and general engineering. It is more prevalent in foreign owned and multinational businesses with UK sites than in domestic companies; and within companies that value and promote education for their employees. There are pockets of individual best practice in some sectors, but UK industry lacks a homogeneous adoption. SME businesses lag behind larger organizations, but all have the opportunity and ability to adopt best practice if the leadership and strategic intent is present. Successful implementation of best practice happens when there is a strategic commitment, top management and workforce engagement, effective communication, and appropriate skills amongst the employees. There is no one prescriptive solution, but each company must assess what is best for them and implement accordingly. The UK has some way to go to achieve best in class performance across the manufacturing sector. However, there is no national or size restriction on adopting best practice to deliver world class performance.

Although a number of practices are currently considered effective in improving business performance, as the global market changes, as products and service offerings merge, future best practices are likely to be different. Current best practices will evolve, adapting to new manufacturing requirements and new practices will emerge as being suitable for delivering a competitive advantage. Best practices that focus on soft skills, on ability to change, on agility and adaptation are likely to come to the fore in manufacturing. That is not to say current best practice will fade. The adaptation of existing best practices is likely to lead to an evolution of these as they are applied to new areas of manufacturing, such as product service systems. Best practice in the future will be different to the best practice of today. Lean production is already the norm in global manufacturing, as are total quality management, six sigma and ISO accreditation. Future best practices are likely to be associated with fast response to market demand, environmental or political change, with application of new technologies such as additive layer manufacturing, with managing extended or distributed supply chains, with data analytics, and with extremely fast time to niche markets for innovative new products.

The USA stands out as the leader in best management practice, but matching and bettering this is open to any country. There is no reason why UK manufacturing cannot improve productivity by identifying and adopting best practices from global manufacturing. Ten potential future areas of best practice are suggested; 1. Supply chain agility and clustering, 2. Application of new technologies, 3. Engagement with universities, 4. Education of manufacturing personnel, 5. New product development and innovation management, 6. Knowledge management, 7. Data analytics, 8. Leadership practices, Change management, and Implementation of best practice, 9. Productivity in product-service systems, and 10. Sustainable manufacturing systems.

By setting a target of meeting and improving on best-in-class levels of productivity an improvement in performance of 30% is realisable. There is no secret to achieving this.

Identification, adaptation and implementation of best practice is open to any business and the UK is particularly well placed with flexible employment legislation and scope for significant improvement. A 30% improvement in GDP per hour worked would deliver an additional £100 billion per year to manufacturing companies' sales. Such an action would support rebalancing the economy.

I. Introduction

Productivity, and practices to improve it, has been the subject of research over many years. Attempts to define and replicate practice to improve performance came to the fore in the 18th and 19th centuries. The work of Henri Fayol (Wood and Wood, 2001) and his associates grew into a larger movement called Fayolism. Frederick Winslow Taylor's work evolved into scientific management (Taylor, 2010). Best practice has evolved across Europe, Japan and USA. From Taylor's scientific management, through Ford's mass production (Batchelor, 1994), Sloan's M-form corporation (Drucker, 1993), Deming's quality movement (Walton, 1992) and Toyota's lean production (Womack et al., 1990), these practices have diffused slowly over time to develop best practice techniques applicable to manufacturing. Adopting best practice is considered to be an effective means to improve performance.

In 2003, Porter and Ketels (2003) noted that the UK had made remarkable progress in halting the country's protracted economic decline of the pre 1980 period. They however also noted that the challenges the UK faced were associated with moving from a location competing on relatively low costs to a location competing on unique value and innovation. They observed that although management cannot be separated from competitiveness issues facing the UK, efforts to upgrade management will not be sufficient to achieve sustained improvement in UK competitiveness. The following year the Advanced Institute of Management Research (AIM) published a report on the Adoption of Promising Practice (2004). The authors found that UK manufacturing organizations on average lag behind competitors such as Germany and Japan in respect of adopting promising practices. Although leading companies can compete with world class organizations, there is a proportionally larger tail in the UK of organizations that fail to adopt best practices. The adoption and utilisation of new management practices is closely linked to productivity. There is evidence that productivity and performance are more influenced by what happens inside the organization than by the regulatory or economic environments in which they operate. However, efforts by UK managers to translate new management practices into improved performance have been both slower and less successful than some of their counterparts in France, Germany and the US. UK managers struggle to recognise the need to change. When they do, they often fail to engage with the deeper causes of the organization's problems; failing to recognise the scale of change required (Antonacopoulou et al., 2010).

Best practice can often found in isolated activities such as just-in-time, Information Technology (IT) systems or Total Quality Management. These approaches can be identified and applied in an equally isolated manner by other companies. To be effective in a business, best practice activity needs to be appropriate for the business sector, linked to strategy and deliver a competitive advantage. Partial implementation of best practices, failure to deliver the desired performance improvement and abandoned programmes are commonplace (Voss, 1995a). The efficiency of a company relative to its competitors determines its market share. The incentive to adopt best practice is greater in markets where companies are more competitive. A short term decline in market share and profits induces a company to adopt best practice. A long term decline in efficiency is correlated with differences in investment (Hay and Liu, 1997).

Best practice ensures companies remain competitive and sustain growth. Best practices evolve; some becoming standard ways of working that are no longer considered best practice, but basic standards. For the future, developing flexibility to respond to future

uncertainties is a key aspect of ensuring company survival and growth (Boyle, 2006; Boyle and Scherrer-Rathje, 2009). Successful organizations pursue a strategic approach of developing a relentless and unremitting focus on searching out, adapting and adopting best practice (Cusumano, 2009).

2. Best practice in manufacturing

Practices are the established processes which a company has put in place to support the way in which the business operates. Best practices are those that lead to world-class performances. World class manufacturing is defined as the point where companies equal or surpass their competitors in every area of their business (Voss et al., 1995b). Best practice can cover numerous areas including agile and lean manufacturing, six sigma, new product development, ISO 9000 and ISO 14000, process analysis and simulation, quality function deployment, theory of constraints, supply chain management, statistical process control, and statistical quality control (Revelle, 2001). There is a link between best performing companies and the adoption of best practice (Quesada-Pineda and Gazo, 2007). It does not matter whether the application or technology solution is a commercial off-the-shelf solution, a custom solution or a hybrid of custom and commercial (Meyers, 2010). However, Voss (2005) argues that there is no such thing as a 'best' practice. Practices evolve, need adapting to the context, and what may be best in one context on day, may not be best in another the next. The more prevalent best practices applied in manufacturing today are noted below.

2.1 Lean

The concept of lean evolved from the Toyota Production System (TPS) into a management philosophy that focuses on removal of any non-value-added activities from the manufacturing process (Womack et al., 1990). Despite much attention and research into the concept of lean, there is no clear definition of lean management philosophy (Alsmadi and Khan, 2010). There have been attempts to define the concept (Hines et al., 2004; Bendell, 2005; Shah and Ward, 2003), whilst others have queried whether this concept is clearly defined (Lewis, 2000; Dahlggaard and Dahlggaard-Park, 2006). Shah and Ward suggest a definition which encompasses people and process components for both an internal perspective (the business) and an external perspective (suppliers and customers). The concept of lean can however be classified into three areas; the philosophy, the principles and the practices (Shah and Ward, 2007; Shah et al., 2008). Lean appears effective as the practices work in unison to deliver results in meeting customer demand and driving waste out of the processes (Furterer and Elshennawy, 2005). However, implementing lean cannot be considered as a quick win (Rowlands, 2006). The greatest challenge to an organization adopting lean is to achieve the maximum possible stability in a changing environment (Rentes et al., 2009).

Many practices considered to be effective in improving operational performance can be grouped in the "lean" category. Shah and Ward (2003) suggest that practices such as Just-in-Time, Total Quality Management and Continuous Improvement Programs, are sub-sets of Lean and should be classed as such. These practices have been evolving and merging such that they represent a body of best practice (Holweg, 2007; Schroeder et al., 2008).

One variant of lean is cellular manufacturing which delivers improvements in lead time, inventory and operating costs (Kirton and Brooks, 1994). Cell manufacturing is defined as 'a group of closely located workstations where multiple, sequential operations are performed on one or more families of similar raw materials, parts, components, products, or information carriers. The cell is a distinctive organizational unit within the firm, staffed by one or more employees, accountable for output performance, and delegated the

responsibility of one or more planning, control, support, and improvement tasks (Hyer and Wemmerlöv, 2002 p18).

2.2 Just in time

Just in Time (JIT) is a lean approach that has seen widespread adoption in manufacturing businesses. It is a system whereby materials and components for production are delivered from the supplier at the point they are needed in the manufacturing process. This means there is no waiting time whilst the materials or components wait prior to being processed. The JIT system includes three elements; people, plant and systems. Successful implementation requires all three elements to be considered (Seyed-Mahmoud, 2004). Small firms benefit from JIT implementation through improvements in production and customer service areas (Golhar et al., 1990). Although JIT delivers benefits to a manufacturing organization, implementing JIT systems means considering the culture of the organization, as the JIT implementation affects the underlying beliefs and values about the production system (Sohal et al., 1993).

2.3 Continuous improvement; Kaizen and Kaikaku

Kaizen or continuous improvement originated in Japan as part of the lean approach. It is a mechanism to remove waste from the manufacturing system by many small improvements. The approach establishes a standard, maintains it, and then improves on it. In this context, a standard is defined as a set of policies, rules, directives and procedures established by management for all major operations. This acts as guidelines that enable all employees to perform their jobs successfully. If employees are unable to adhere to the standard, management either provide training, or review and revise the standard (Wittenberg, 1994). Although both advocate improvement, kaizen differs from kaikaku, which is a radical change approach rather than the evolutionary change of kaizen. Whilst kaizen is fundamental to the Toyota Production System, kaikaku is a fundamental concept of the executive system used at Toyota (Munro, 2012). Kaizen can deliver improvements in quality, safety and operating costs (Lydon, 2007).

2.4 Total Quality Management and ISO 9000

ISO 9000 is a quality management standard that defines the management processes and systems to be applied to ensure quality (BSI, 2013). Total Quality Management (TQM) is defined as an integrated approach for delivering competitive advantage by continually improving all aspects of organizational culture (Tobin, 1990). It goes beyond the systems approach of ISO 9000 and addresses the underlying beliefs and attitudes that influence behaviours. The focus is on the basic assumptions underlying the more visible levels of quality management (Kujala and Lillrank, 2004). The implementation of ISO 9000 often remains superficial (Boiral and Amara, 2009). Many companies, regardless of size, often apply ISO 9000 and TQM as a means of improving performance. There is evidence that TQM activities are associated with improved competitiveness, whereas ISO 9000 on its own does not deliver the same level of performance improvement (Prabhu et al., 2000a).

2.5 ISO 14000

ISO14000 is an environmental management system. It provides a mechanism for companies seeking to identify and control their environmental impact and constantly improve their environmental performance (ISO, 2012). There is some evidence that adopting ISO14000 can deliver economic benefit, but the main benefit is to the intangible assets of the company (Teng, 2011).

2.6 Health and safety

Ensuring a safe working environment is considered best practice. Many organizations which exhibit best practice in terms of health and safety often demonstrate good relationships with their employees (Cork, 2005). Practical guidance for improving health and safety practices can be found on the Health and Safety Executive website (Health and Safety Executive, 2012). A formal accreditation system for managing health and safety is OHSAS18000 (Occupational Health and Safety, 2012). This is a similar system for management and compliance as ISO 9000 and ISO 14000.

2.7 Six Sigma

Six Sigma evolved from taking a statistically driven perspective to improving manufacturing processes. The capability of a manufacturing process to consistently deliver product to the required standard can be expressed in terms of the number of defective products produced. A six sigma process is one in which 99.99966% of the products manufactured are statistically expected to be free of defects (3.4 defects per million). Motorola set a target of “six sigma” for all its manufacturing operations, and this term became synonymous with the practices used to achieve this level of performance (Placzkowski, 2001). Adopting Six Sigma improves organizational performance, through the efficiency with which employees are deployed, but also through improved productivity (Shafer and Moeller, 2012). Six Sigma works in both large and small companies (Kumar and Antony, 2008). However the impact of six sigma across small to medium sized enterprise (SME) companies is less prevalent. Many SMEs are not aware of six sigma and many lack resource to implement six sigma projects. Linking six sigma to customers and business strategy are the most critical factors for the successful deployment of six sigma in SMEs (Antony et al., 2005).

2.8 5S

5S is a systematic approach to organization that consists of five steps. Although originating in Japan and having Japanese names for each step (1. seiri, 2. seiton, 3. seiso, 4. seiketsu, and 5. shitsuke), the translation to English usually considers the five steps as, 1. sort, 2. set in order, 3. shine, 4. standardize, and 5. sustain. 5S creates an environment that is disciplined, clean and well ordered (Chapman, 2005). The implementation of a 5S programme can create a culture of continuous improvement across the organization (Shil, 2009). 5S can facilitate improved operational performance, particularly in the areas of quality and productivity (Bayo-Moriones et al., 2010). As with TQM, management of both the technical (visible) and cultural (invisible) approaches is required for each of the 5S components to ensure productivity gains are realized (Gapp et al., 2008).

2.9 Failure mode and effects analysis

Failure mode and effects analysis (FMEA) is a technique that is widely applied in the automotive sector. FMEAs help manufacturers to prevent defects, improve safety and increase customer satisfaction. Most are conducted in the product design or process development stages (Johnson, 2002). FMEA acts as a mechanism to facilitate knowledge transfer between development teams (Frank and Echeveste, 2012). There is often reluctance amongst product engineering and manufacturing engineering personnel to take a leading role in the preparation of design and process FMEAs respectively. The main reasons for this relate to a perceived lack of time or lack of understanding of the technique's potential (Aldridge et al., 1991).

2.10 Quality Function Deployment

Like FMEA, Quality Function Deployment (QFD) is widely applied in the automotive sector. Developed in the late 1960s to help design supertankers in Mitsubishi's shipyards in Kobe, Japan, the technique involves taking customer requirements and turning them into technical specifications for the finished product (Maire et al., 2005). QFD articulates and ranks customer requirements and defines the technical requirements needed to meet those requirements (Kinni, 1993). QFD is most likely to have a positive benefit when management support for QFD is prevalent and where customer data gathered for the project are used (Cristiano et al., 2001; Cauchick Miguel, 2005; Fegh-hi Farahmand, 2009). As with FMEA, QFD is a mechanism to share knowledge across sites or divisions (Jussel and Atherton, 2000). Despite much literature on the tools and techniques for applying QFD, there is little on how QFD can be introduced into the management system of an organization (Parkin et al., 2002).

2.11 New product development

Creating a flow of innovative new products and reducing the time taken to design and market new products are key greatest challenges facing UK's manufacturing industry. Working collaboratively with suppliers is considered best practice in new product development. The importance of sharing knowledge between buyer and supplier in this context is well recognised, although comparatively little research exists on the inter-company socialisation mechanisms that facilitate it (Lawson et al., 2009). Adaptive leadership is used in successful new product development (NPD) environments where strong leaders are not necessary for successful outcomes (Olsson and Wass, 2001). Product lifecycle management (PLM) systems have the potential to improve the quality of design decisions and minimise manufacturing problems during new product development. However, providing a source of best practice is difficult due to the complexity of the viewpoint relationships between products and the processes and resources used to produce them (Gunendran and Young, 2010). There are differences between the specific practices that NPD practitioners from SMEs and large companies consider to be best practice. There is limited value in developing theories and models about best practice in managing NPD unless these models and theories are fully diffused and can be made useful to NPD practitioners (Nicholas et al., 2011).

2.12 Total Productive Maintenance

Total productive Maintenance (TPM) aims at providing the most efficient use of equipment. As with lean, the practice engages all employees from top management down, and implements action, based on small autonomous teams, to ensure maximum efficiency and availability of manufacturing equipment (Bamber et al., 1999). The basic measure of TPM performance is the overall equipment effectiveness (OEE) value, which is described by Nakajima (1989) as the driving force and direction for improvement based activities within manufacturing operations. A recent development of TPM is the application of six sigma practices to TPM (Thomas et al., 2008).

2.13 Supply chain management

Best practice in supply chains is represented in the areas of IT tools, make-or-buy procedures, supplier searches and progress reporting, supplier-customer relationship management and quality management (Andersen et al., 1999). There is increasing emphasis on alliances, networks, and supply chain management as mechanisms by which manufacturing companies can achieve competitive advantage. US automotive manufacturers have historically managed the majority of their suppliers using an arm's-length model. Korean automotive manufacturers have managed suppliers primarily as partners, whilst Japanese automotive manufacturers have different relationships with suppliers depending on the nature of the component. Only Japanese companies have strategically segmented suppliers to realize many of the benefits of both the arm's length as well as the partner models (Dyer et al., 1998). Supply chain best practices align people, processes and technology (Yacovone, 2007). Supply chains operate most effectively with a close relationship between all partners. This partnership approach requires realistic working standards and practices. Successful supply chains developed in automotive and aerospace where well developed relationships and supply systems facilitated the adoption of lean systems (Barclay, 2005), and these are often used as best practice exemplars. Sourcing is the choice of who will perform a particular supply chain activity such as production, storage, transportation, or the management of information. This is a key aspect of Supply Chain Management and has had significant influence on sourcing components for companies outside the UK (off-shoring). In more recent times the process has been reversed with companies realising the benefits of having a shorter supply chain and returning to UK or European suppliers. Decisions are made balancing between efficiency with responsiveness (Chopra and Meindl, 2012). In turbulent and volatile markets where life cycles shorten and global economic and competitive forces create additional uncertainty, a more responsive approach has been developed to supply chain management. Where there is risk attached to lengthy and slow-moving logistics supply pipelines become unsustainable, forcing organizations to review how their supply chains are structured and managed. The use of "agility" – the creation of responsive supply chains allows organizations to respond to these demands. Agility operates in concert with lean, rather than as a lean practice (Christopher, 2000).

2.14 Other

Manufacturing companies with a reputation for delivering high levels of customer service have similar characteristics that enable them to concentrate on satisfying the customer. These companies generally outperformed the average company in their industry in terms of financial performance after adopting a customer service strategy (Griffin et al., 1995).

Best practice in management accounting enables managers to obtain relevant information for meaningful decision making and can contribute to the success of a company (Alleyne and Weekes-Marshall, 2011).

Practices that transfer power to employees, often described as high-performance practices, can raise productivity (Cappelli and Neumark, 2001). Best practice in Human Resource Management (HRM) on organizational performance has tended to focus on a universally applicable best practice model of high commitment management (Purcell, 1999).

Concepts of mind set and lateral thinking are related to the top-down introduction of a step change in performance, whilst total quality programs develop the culture necessary for bottom-up continuous improvement. Successful companies will run both approaches in parallel (Hall, 1996). Best practice in leadership, customer and market focus, human resource management, process management and process innovation all contribute to improving company performance (Seedee, 2012). It is sometimes difficult for a company to clearly define what a best practice is and there is a lack of methods which could help it to identify those best practices (Maire et al., 2005).

3. Developing best practice through benchmarking

Benchmarking has developed rapidly since its introduction by Xerox in the late 1970s (Andersen and Camp, 1995). Benchmarking is a process of identifying, sharing and using knowledge and best practices (Maire, 2002). A benchmarking study includes analysis of the organization's own process, and study of benchmarking partners' processes. An analysis of the differences between the two allows development of improvements based on what is learned from the benchmarking partners (Andersen, 1999). Benchmarking identifies practices that are considered to be the best available. Practices identified should have an effective contribution to improving customer satisfaction (Maire et al., 2005), but the transfer mechanism is a key aspect in realising benefit from the process (Andersen and Camp, 1995). Companies that have benchmarked themselves, and find significant gaps, are generally keen to improve (Van Landeghem, 2007). Whilst there are reservations about the effectiveness of benchmarking from Womack and Jones (1996) who consider it to be a waste of time unless used to convince sceptical managers, benchmarking remains effective in transforming an organization. This transformation is facilitated through management of knowledge and the practice of continuous learning and improvement (Knuf, 2000). Aspiring companies must be prepared to invest time and effort in finding best-practice examples (Wiarda and Luria, 1998).

Best practice focus has evolved from benchmarking as a means to improve company performance through the identification of best practice, to the need to identify, manage and transfer best practices (Davies and Kochhar, 2002). It is a learning tool that can reduce uncertainty in the organization by referring to peer experience (Knuf, 2000). Having a best practice program is associated with traits such as proactivity, internal communication, training and leadership that should be commercially advantageous (Beaumont, 2005). However, benchmarking on its own it will not improve a business. It is the vision, strategic direction, energy and teamwork of the organization that delivers productivity improvements (Hanson and Voss, 1995). The use of benchmarking has changed to a great extent over the last 15 years. Some best practices may not be suitable at all levels of operation and therefore need to be applied and used carefully (Putkiranta, 2012). There appears to be no correlation between market share or profit loss and the trigger point for adopting best practice. Some companies have ceased trading before taking action (Barker, 1998).

4. Best practice in UK manufacturing by sector

In a study of small companies in Europe, Voss et al (1998) found that few UK SMEs are in the world class category, and that their competitive advantage comes from speed, responsiveness and proximity to customers. Larger companies outperform the rest both in terms of their success in implementing best manufacturing practices and in achieving high operational performance. There is no appreciable difference between industrial sectors in implementing best practice and in achieving high performance (Ulusoy and Ikiz, 2001). Amongst UK SMEs the adoption of best practice amongst key sectors was found to be as noted in Table 1 (Khan et al., 2007).

Table 1 Percentage adoption of practices amongst UK SME businesses
(adapted from Khan et al., 2007)

	General Engineering	Automotive	Medical	Aerospace Engineering	Leisure and Marine	Plastics Engineering
Benchmarking	48	75	20	83	40	50
QFD	10	42	not available	0	20	12
FMEA	24	42	not available	0	20	25
Training for Management	20	59	20	58	40	50
Training for Operators	15	73	30	33	20	23
Soft Skills Training	22	58	0	23	20	not available
TQM	31	75	40	67	25	38
SPC	31	50	60	83	0	38
Kaizen	23	58	20	50	20	21
TPM	16	25	0	not available	10	25
Health and Safety Policy	94	100	100	100	100	100
ISO 9000	75	91	100	100	60	87
ISO 14000	5	17	0	0	0	0

A more recent study of operational excellence amongst UK manufacturing organizations (Szwejczewski and Marsh, 2012) indicated that although there has been an improvement in skill levels, the adoption of new management practices is not as extensive as previously believed. The distribution of practices across the manufacturing sectors is shown in Table 2.

Table 2: Practice adoption across industry sectors (from Szwejczewski and Marsh, 2012)

Practice	Percentage adoption of practice by sector					
	Overall	Process	Eng	Elec	Food / Drink	Other
Team working	97%	100%	98%	94%	100%	92%
Individual appraisals	79%	50%	75%	88%	78%	92%
ISO14000	61%	100%	59%	47%	78%	58%
Continuous improvement	41%	0%	32%	47%	67%	58%
TPM	41%	25%	43%	35%	44%	42%
5S	40%	25%	36%	53%	56%	25%
Customer or product focused cells	35%	0%	34%	59%	22%	25%
NPD -simultaneous engineering	35%	50%	48%	29%	0%	17%
One piece flow (lean)	28%	25%	34%	35%	0%	17%
Zero buffer (JIT)	26%	0%	30%	29%	22%	17%
JIT delivery to customers	19%	0%	16%	24%	22%	25%
Annualised Hours (Flexible working)	17%	0%	7%	35%	44%	17%
Six sigma	13%	0%	9%	24%	11%	17%

This report suggests that team working is the most widely adopted practice in the sectors analysed. Team work encourages engagement and facilitates the development of a culture of best practice adoption. However, despite much exhortation to adopt best practice and to innovate, manufacturing companies pay only scant attention to best practice implementation (Szwejczewski and Marsh, 2012). It is noticeable that the food and drink sector which experiences both seasonality and cyclicity of demand leads adoption of annual hours working. This is a mechanism to spread the working hours across the year rather than the week and facilitates adjusting capacity to match demand (Gregory, 2002).

Within UK SMEs, ISO 9000 may be a foundation for embarking on lean or six sigma practices as a means for delivering productivity improvements. There are differences in the quality management practices, such as knowledge transfer to employees and customer focused measures between six sigma and ISO 9000 accredited SMEs. There is a significant difference in performance of six sigma or lean companies against ISO 9000 certified companies in both strategic and operational measures of company performance (Kumar and Antony, 2008). This again reinforces the perspective that SMEs lack knowledge and are unwilling to commit time to facilitate adoption of best practice. There is strong evidence that the adaptation and adoption of best practice can lead to high levels of performance amongst SME businesses (de Búrca et al., 2012).

Smaller SMEs display poor adoption of best practices. Companies with fewer than 20 employees tend to rely on their particular circumstances or on the skill-set or relationships of their leaders. Larger companies, between 20 and 200 employees, were

more likely to adopt best practice from other businesses (Cagliano et al., 2001). Khan et al (2007) suggest that SMEs are increasingly working with larger companies to improve competitiveness but this is mainly limited to automotive and aerospace. Training is limited, tending to be restricted to management, and training in soft skills is particularly lacking. SME managers are not generally conversant with best practice methods and the use of benchmarking. Benchmarking, as a means to seek out and implement best practice, is a key area of weakness for some smaller companies (Prabhu et al., 2000b). Larger companies have resources and the incentive of maintaining a large market share to employ better management than smaller companies. As company size increases, the management practices improve (Bloom et al., 2012a). Amongst the automotive components industry, domestically owned companies could learn from their foreign owned counterparts in achieving best practice (Clifton, 2001). A Benchmark Index report (Davies, 2009) noted that within the UK, the sectors that created most wealth in manufacturing were metal products, chemicals and food – sectors not associated with the widespread adoption of best practice. Key enablers for manufacturing companies improving performance were training of employees and recruitment of graduates to the business.

In a study of management practices undertaken by Bloom et al (2007) the authors note that the UK has one of the most flexible labour markets in the world and its people management practices reflect this. They note however that the UK is poor in operations management, suggesting that UK manufacturers have been slow to adopt many of the modern production techniques that have been applied with great success elsewhere. The authors suggest that while the UK's flexible labour market (and competition from a thriving service sector) forces firms to work hard to attract good people, they are far less effective at equipping their employees to deliver improved performance and at motivating them to do their best.

Within the UK, best practice is most evident within automotive and aerospace companies, followed by plastics and general engineering. It is more prevalent in foreign owned and multinational businesses with UK sites than in domestic companies; and within companies that value and promote education for their employees. There are pockets of individual best practice in some sectors, but UK industry lacks a homogeneous adoption. SME businesses lag behind larger organizations, but all have the opportunity and ability to adopt best practice if the leadership and strategic intent is present.

5. Best practice - implementation

Having identified best practice, the problem of implementing it into the company's organization must be resolved. Best practice examples are generally descriptive. They are context specific and must be investigated in the context where they are studied. There is no standard recipe for how to implement lean or six sigma. The poor uptake of promising practices by a large number of UK organizations is noted by the authors of the 2004 AIM report (Lesure et al., 2004). For an effective implementation a holistic analysis should be carried out that recognises the potential and impact of the practice on all areas of the business, rather than within the target area (Davies and Kochhar, 2002). Rather than adopt a prescriptive model of best-practice, companies should develop procedures which more adequately reflect their inherent needs and the types of project they undertake (Maffin and Braiden, 2001). International productivity differences can be examined by bringing managers from the relatively weak performing economies to factories in best-practice economies (Hitchens et al., 1991). Learning to implement best practice effectively provides a longer-term approach to improve effectiveness of the implementations. Education and training are key aspects of effective best practice implementation. Using a National Vocational Qualification in business-improvement techniques can be used a mechanism to educate employees in best practice transfer (Pollitt, 2012).

Lean is a management philosophy focused on identifying and eliminating waste throughout a product's entire value stream, extending not only within the organization but also along the company's supply chain network. Lean offers significant benefits in waste reduction, and increased organizational and supply chain communication and integration. Visible management commitment to long term sustainment, enabling and encouraging autonomy, focus on mid to long-term goals, communicating lean successes and continual re-evaluation were all aspects that facilitated successful and sustained lean implementation (Scherrer-Rathje et al., 2009). Lean is effective when considered as part of a high commitment culture. Management teams that consider enablers, such as autonomy and the perception of control; whilst mitigating the impact of inhibitors such as blame, long hours, poor ergonomics and tools are more likely to achieve a successful lean implementation (Angelis et al., 2011). Sim and Chiang examined (2012) organizational issues which enhance or impede successful lean implementations. Job satisfaction, management support in addressing effort-reward equity concerns and job security were found to be key aspects associated with successful lean implementations.

Best practice requires a culture that allows it to prosper (Riel, 2012). A sustainable implementation is difficult and time consuming. Simply replicating another organization's best practice is an unrealistic approach. Every organization is unique, the pressures, structures and cultures for each organization have a significant impact on the implementation success. Lean thinking, Toyota-style, involves a much more pervasive and deeper transformation than many organizations anticipate. Implementations that fail can be attributed to culture and management of change issues. Employee commitment is required as much as financial investment to ensure success (Bhasin, 2012).

Developing a culture where continuous improvement is seen as normal and where there is no fear about raising difficult issues in the pursuit of improvement is essential (Womack et al., 1990). Training helps enable this culture change (Cooper, 1994). However, assuming management practices are the only driver of higher productivity may be misleading (Battisti and Iona, 2009). Companies that take a strategic approach to

identifying and adopting best practice are more likely to generate performance improvement than those taking an ad hoc approach (Seedee, 2012; Sheather, 2002). Cost of adoption, external pressures, and satisfaction with the existing practice influence adoption of best practice (Ungan, 2004). Engagement of all employees is essential for effective implementation (Aman Deep et al., 2008). An attitude change from employees may be necessary to facilitate adoption (Cooke, 2000). Poor results from best practice implementation can be due to a failure to link practices to specific and measurable objectives, to a failure to prioritize best practices, and to a lack of analysis of necessary infrastructure practices (Davies and Kochhar, 2000). Companies may not be successful in implementing best practice if managers do not offer adequate support (Ungan, 2005), although the existence of a champion is not essential for successful implementation (Ungan, 2007). Determinants of successful best practice implementation are management, location, export growth, type of manufacturing and competitiveness (Calabrese, 2009). Top management should not only demonstrate commitment and leadership, but must also work to create interest in the implementation and communicate the change to everyone within the organization (Rentes et al., 2009). Managing implementation requires commitment to long-term, strategic workforce planning (Divakaran et al., 2012). Successful best practice implementation involves innovation, action learning, and extends throughout the organization (Parnaby and Towill, 2012). Organizational context significantly shapes NPD practice performance (Oliver et al., 2004).

The key aspects to successful implementation of best practice are a strategic commitment, top management and workforce engagement, communication and adequate skills amongst the employees. There is no one prescriptive solution, but each company must assess what is best for them and implement accordingly.

6. Support for best practice in the UK

There are many specialized consultancies offering support for the adoption of best practice, but these tend to be niche based and focus on specific practices. Large companies may employ their own experts in implementation and use these people to diffuse best practice. For SME businesses where resources are limited, support for best practice adoption is usually sought from external bodies. Within the UK a number of frameworks are available to support the adoption of best practice. A programme of visits encourages sharing and adoption of best practice between UK companies. This is achieved by organising visits to award winning companies recognised for their best practice and success. A number of benchmarking sites are made available through national and regional initiatives. These allow companies to visit other organizations declaring best practice and learn from their experiences (Onsite Insight, 2012).

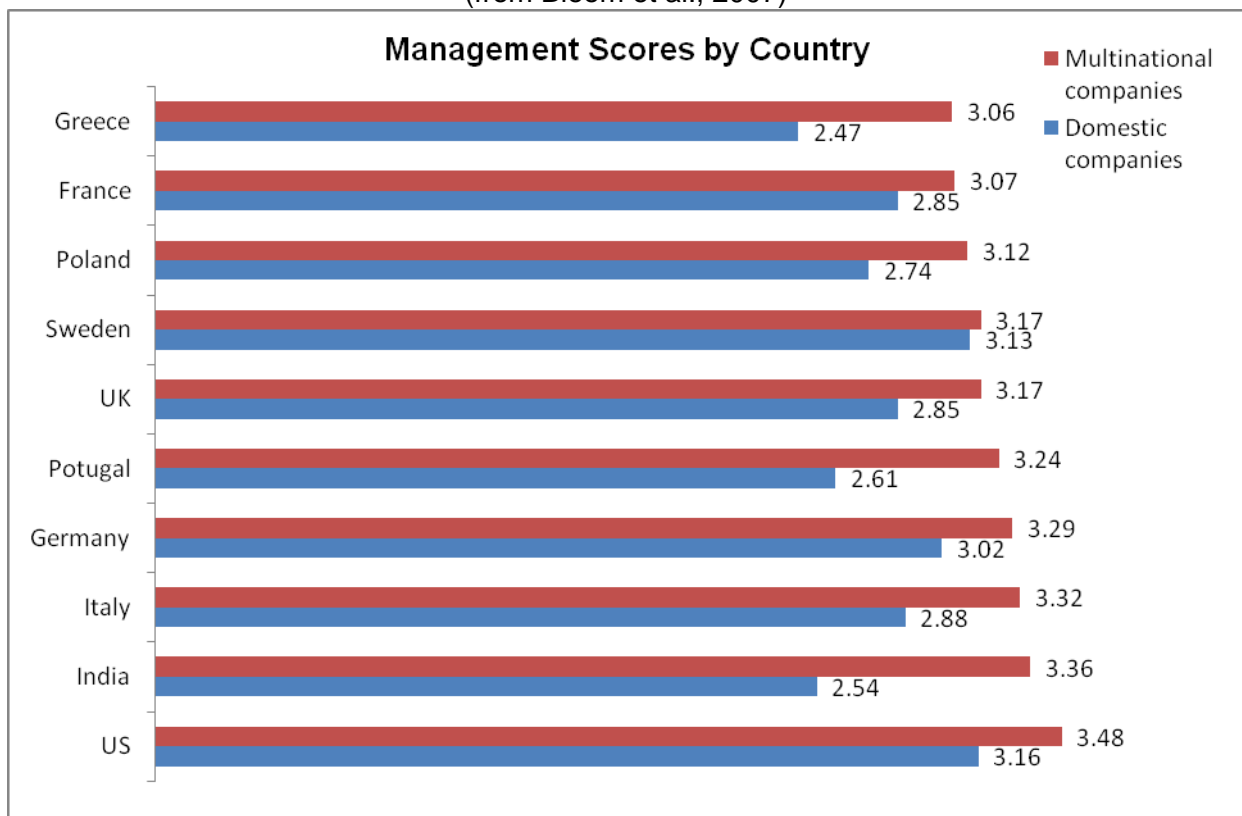
Manufacturing best practice awards are used as a means of identifying and recognising best practice. These best practice sites can then be used for benchmarking visits for other companies seeking to adopt best practice. In the UK, examples are Works Management's Best Factory Award (Works Management, 2012), the Manufacturer magazine, Manufacturer of the Year Award (The Manufacturer, 2012), the Institution of Mechanical Engineers' Manufacturing Excellence (MX) Awards (Institution of Mechanical Engineers, 2012) and the EEF Future Manufacturing Awards (EEF, 2012b). Award winning companies often offer best practice visits to other UK businesses as a means of observing the facility at which the best practice operates.

The Manufacturing Advisory Service (MAS) provides support for finding and implementing best practice (MAS, 2013). MAS also runs Best Practice Clubs to promote sharing of best practice across UK businesses (MAS, 2012). A similar organization to support manufacturing in Scotland is provided by Scottish Enterprise (Scottish Enterprise, 2012). Best practice visits are also offered by a number of regional organizations. Highlands and Islands Enterprise promotes best practice visits for manufacturing companies in the region (Highlands and Islands Enterprise, 2012). In a similar manner London Excellence promotes best practice sharing in their area (London Excellence, 2012). Trade bodies, such as the EFF (EEF, 2012a) and FIRA (FIRA, 2013) offer their members access to best practice visits and sharing of best practice through their network. Cooperatives have developed that share best practice amongst non-competing companies in the same region (West Midlands Manufacturing Club, 2012; MAN Group, 2012). Whilst there is some support for identifying best practice, it is patchy and lacks a national cohesiveness.

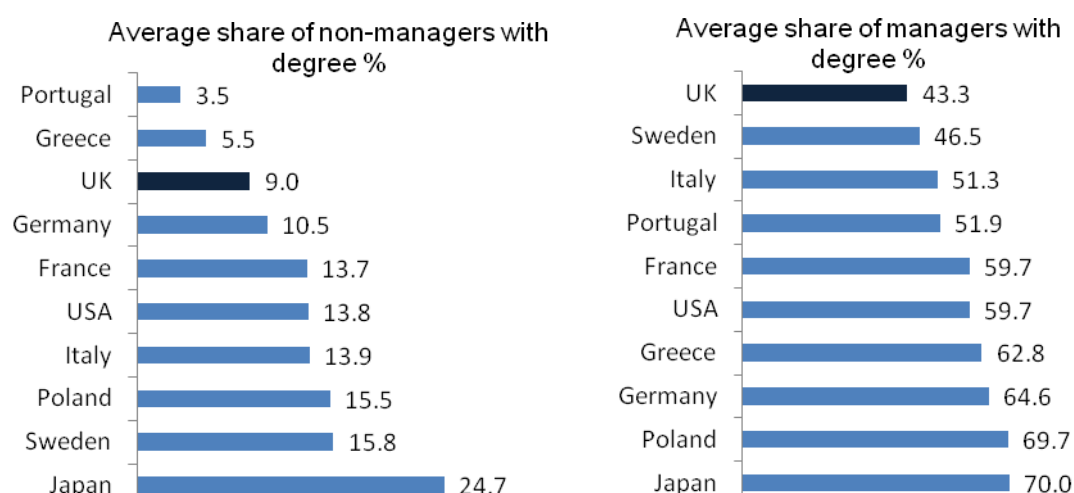
7. Best practice in UK and non-UK firms

A recent analysis of labour productivity in the European Union (EU) showed Portugal made significant improvement until the 1990s, when it started a sharp decline. Sweden and Denmark moved from well above average in 1965 to below average by 1998. Ireland showed the most dramatic productivity improvements. Denmark, Sweden and the UK were below the EU average (Färe et al., 2006). A more recent study in 2007 found that low standards of productivity remain a concern for the UK. Productivity was behind many developed world competitors and whilst productivity had improved, the gap between the UK and the USA remained large. The UK had a lower score for management practice than USA, Sweden, Japan and Germany (the dimensions used for scoring management practice are shown in Table 3). Multinational companies were found to be best managed (Bloom et al., 2007). Multinational and domestic management practice by country is shown in Figure 1.

Figure 1: Multinational and domestic company management score by country
(from Bloom et al., 2007)



A driver of the UK average management score is its relatively low skill levels. The percentage of employees by country with degree level education is shown in Figure 2.

Figure 2: Average share of employees with a degree by country (from Bloom et al., 2007)

A more recent study ranked management scores across several countries from worst practice to best practice. The United States scored highest followed by Germany, Sweden and Japan. Great Britain came eighth, Australia ninth and Northern Ireland tenth (Bloom and Van Reenen, 2010). The scoring is derived from an interview-based evaluation tool that defines and scores from 1 (worst practice) to 5 (best practice) for 18 basic management practices. The management practices used in this tool are shown in Table 3.

Table 3: Management Practice Dimensions (Bloom and Van Reenen, 2010)

Category	Score of 1 to 5 based on:-
1) Introduction of modern manufacturing techniques	What aspects of manufacturing have been formally introduced, including just-in-time delivery from suppliers, automation, flexible manpower, support systems, attitudes, and behaviour?
2) Rationale for introduction of modern manufacturing techniques	Were modern manufacturing techniques adopted just because others were using them, or are they linked to meeting business objectives like reducing costs and improving quality?
3) Process problem documentation	Are process improvements made only when problems arise, or are they actively sought out for continuous improvement as part of a normal business process?
4) Performance tracking	Is tracking ad hoc and incomplete, or is performance continually tracked and communicated to all staff?
5) Performance review	Is performance reviewed infrequently and only on a success/failure scale, or is performance reviewed continually with an expectation of continuous improvement?
6) Performance dialogue	In review/performance conversations, to what extent is the purpose, data, agenda, and follow-up steps (like coaching) clear to all parties?
7) Consequence management	To what extent does failure to achieve agreed objectives carry consequences, which can include retraining or reassignment to other jobs?
8) Target balance	Are the goals exclusively financial, or is there a balance of financial and nonfinancial targets?
9) Target interconnection	Are goals based on accounting value, or are they based on shareholder value in a way that works through business units and ultimately is connected to individual performance expectations?
10) Target time horizon	Does top management focus mainly on the short term, or does it visualize short-term targets as a "staircase" toward the main focus on long-term goals?
11) Targets are stretching	Are goals too easy to achieve, especially for some "sacred cows" areas of the firm, or are goals demanding but attainable for all parts of the firm?

Category	Score of 1 to 5 based on:-
12) Performance clarity	Are performance measures ill-defined, poorly understood, and private, or are they well-defined, clearly communicated, and made public?
13) Managing human capital	To what extent are senior managers evaluated and held accountable for attracting, retaining, and developing talent throughout the organization?
14) Rewarding high performance	To what extent are people in the firm rewarded equally irrespective of performance level, or are rewards related to performance and effort?
15) Removing poor performers	Are poor performers rarely removed, or are they retrained and/or moved into different roles or out of the company as soon as the weakness is identified?
16) Promoting high performers	Are people promoted mainly on the basis of tenure, or does the firm actively identify, develop, and promote its top performers?
17) Attracting human capital	Do competitors offer stronger reasons for talented people to join their companies, or does a firm provide a wide range of reasons to encourage talented people to join?
18) Retaining human capital	Does the firm do relatively little to retain top talent or do whatever it takes to retain top talent when they look likely to leave?

Table 4 shows the outcome of the 2010 study. This indicates that GB management practice, scored at 2.98 is just above the average of the group at 2.94.

Table 4: Management Practice Scores by Country
(from Bloom and Van Reenen, 2010)

Country	Overall management practice score
Australia	2.99
Brazil	2.69
Canada	3.13
China	2.64
France	3.00
Germany	3.18
Great Britain	2.98
Greece	2.65
India	2.65
Italy	2.99
Japan	3.15
Northern Ireland	2.91
Poland	2.88
Portugal	2.79
Republic of Ireland	2.84
Sweden	3.18
United States	3.33
Average	2.94

This is shown graphically in Figure 3. It is noticeable that USA, Germany and Japan feature at the high end of management practice scores. Much of the difference in the average management score of a country is due to the size of the long tail of very badly managed companies (Voss et al., 1995b; Bloom and Van Reenen, 2010). Higher scoring management practices are not necessarily detrimental to the workforce. In a survey of medium-sized manufacturing firms in the USA, France, Germany and the UK, work-life-balance (WLB) outcomes are associated with better management, in that well managed companies are both more productive and offer better conditions for their employees. Tougher competition increases average management quality but does not negatively

affect employees' working environment (Bloom and Van Reenen, 2006). UK SME companies tend to be underperforming in comparison to companies in France and Germany (Khan et al., 2007). There is however evidence of improvement in partnership sourcing, product focus and innovation (Yarrow et al., 2004).

Figure 3: Chart of management practice scores by country
(from Bloom and Van Reenen, 2010)

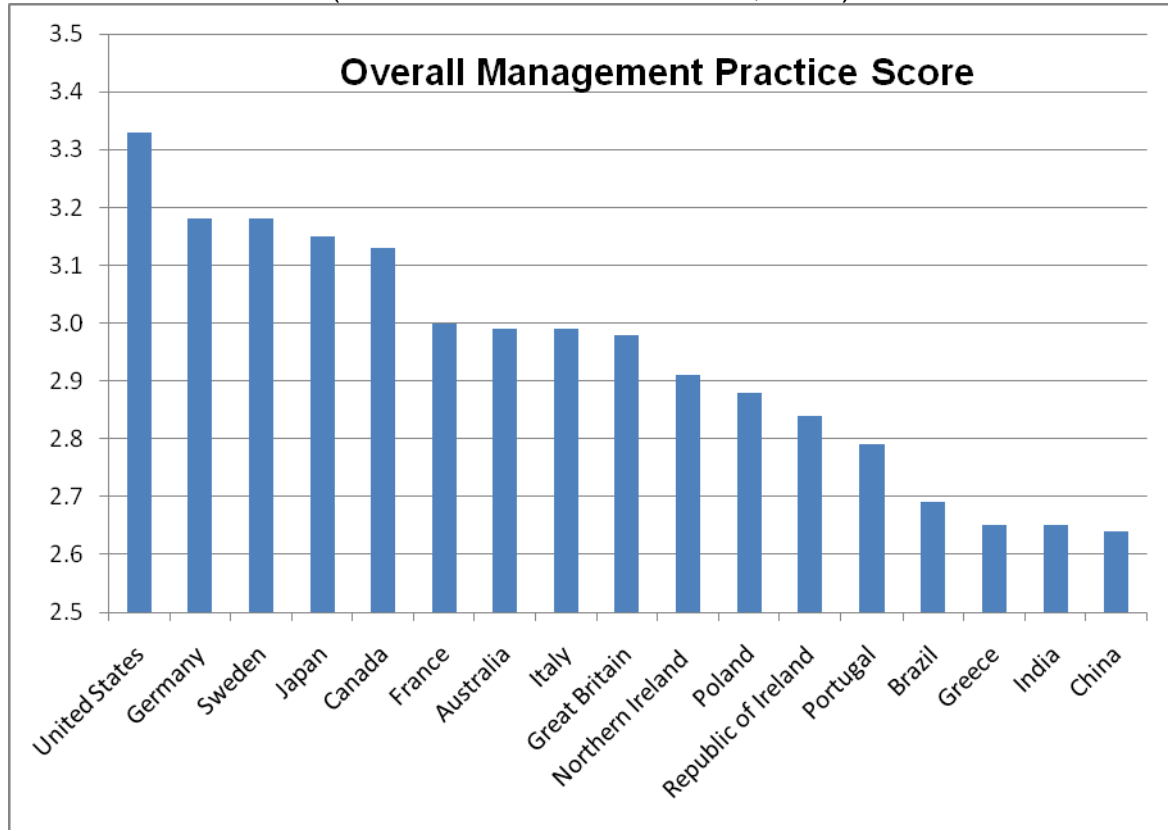
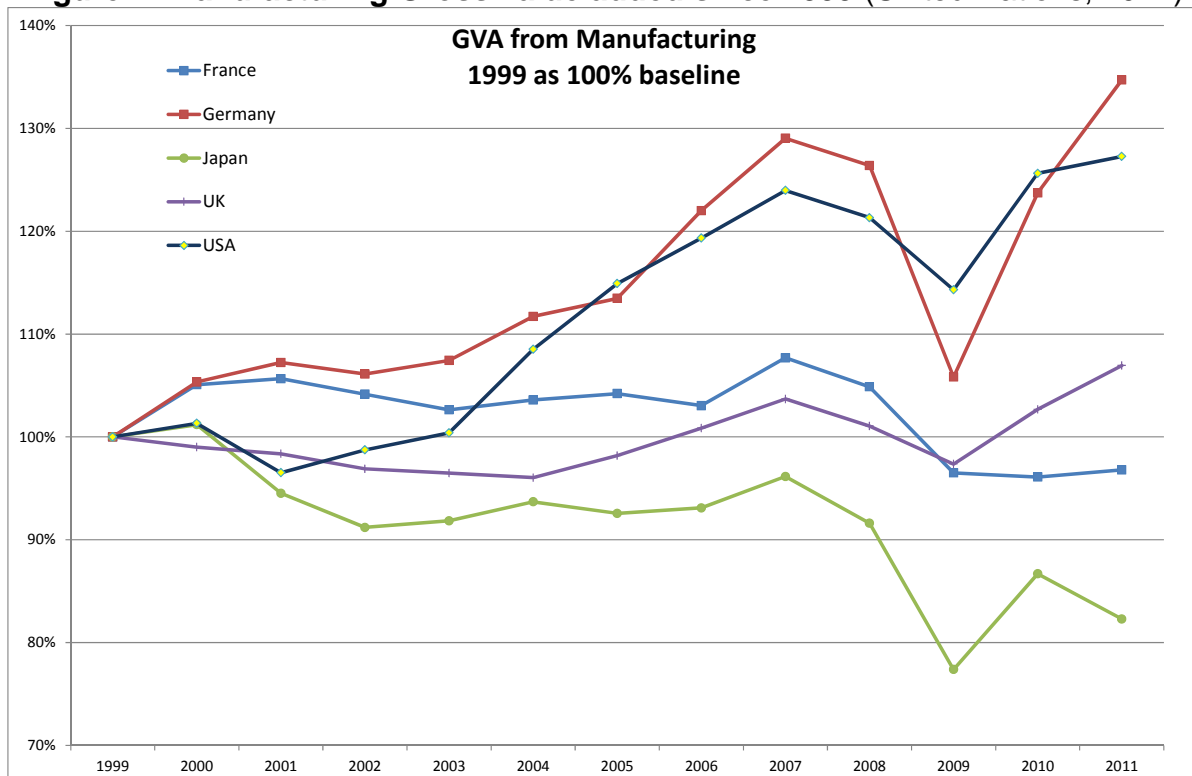


Figure 4: Manufacturing Gross value added since 1999 (United Nations, 2012)

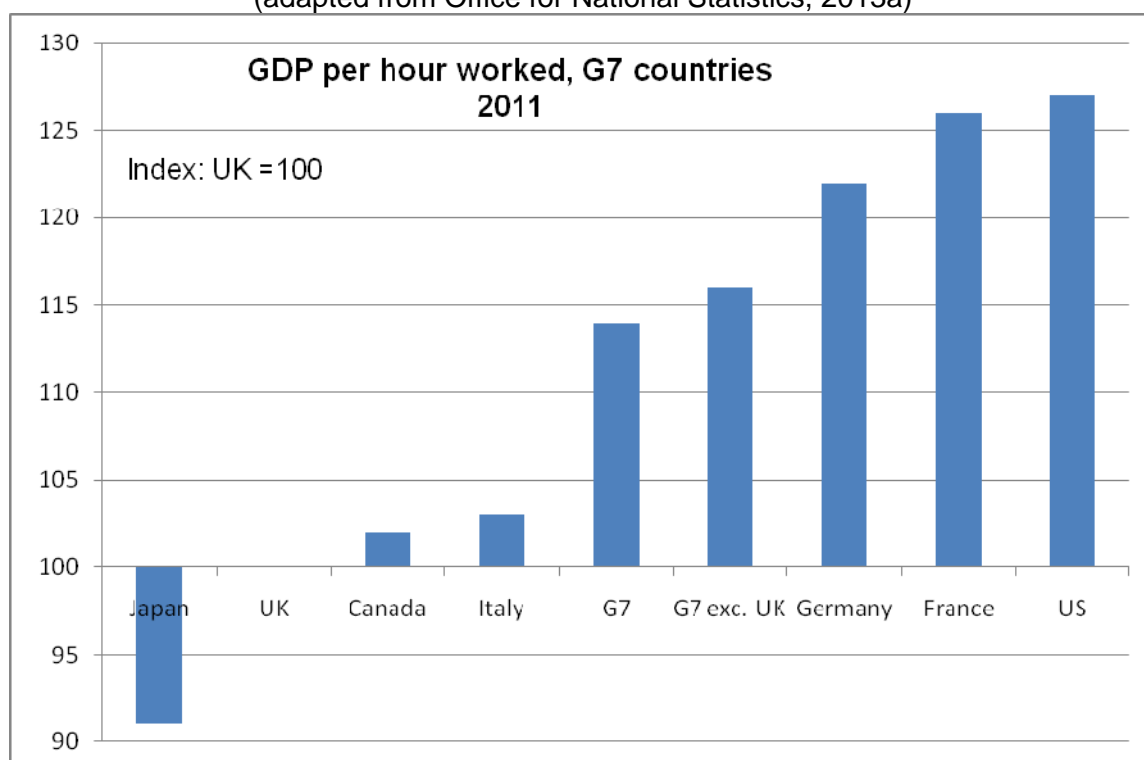


United Nations data for manufacturing gross value added (GVA) for key UK competitor countries since 1999 is shown in Figure 4 (United Nations, 2012). This indicates the dominance of Germany and USA in manufacturing performance.

Voss et al suggested that in a four country study in 1995, Germany had the best practices, Netherlands the best performance and Germany had the best overall practice and performance combination (1995b). Despite the rise of the new economies in China, India and other rapidly developing countries, the USA is still the leader and is maintaining its competitive advantage in both best management practice and strong productivity. Investment, innovation and skills are three areas in which UK manufacturing industry has fallen behind its rivals in France and Germany. Two key UK weaknesses in best practice are a lower uptake of lean and less use of high performance working. This is impacted by three factors, investment, skills, and innovation (Pullin, 2003). However, despite the gap between UK and other countries, between SME and large companies and between multinational and domestic companies, dramatic improvements in productivity are readily, and universally, available to all business enterprises simply through the adoption of globally existing best practices (Mannion, 2009). A recent report into the contribution of mid-sized companies to the UK economy found that UK companies suffered from a productivity problem and poorer levels of operational excellence when compared to German companies. The authors suggested a short-term focus in UK mid-sized companies may be contributing to this problem (Roper and Malshe, 2012).

Productivity analyses conducted by the Office for National Statistics (2013a) indicated that output per hour in the UK was 16 percentage points below the average for the rest of the major industrialised economies in 2011. This was the widest productivity gap since 1993. Final estimates for 2011 showed that on an output per worker basis, the UK was above that of Japan, but below that of the remaining G7 countries (Figure 5). The UK was lower than the US by the greatest margin since 1990, when this series begins.

Figure 5: GDP per hour worked for G7 countries for 2011
(adapted from Office for National Statistics, 2013a)



On an output per worker basis, UK productivity was 21 percentage points lower than the rest of the G7 in 2011. However, in 2011, UK output per hour grew roughly in line with the average of the rest of the G7, and faster than the US and Germany. UK output per worker was broadly unchanged between 2010 and 2011. Since 2007, growth of UK output per hour and output per worker has trailed that of the US, Japan and Canada, but has been broadly similar to that of Germany and Italy. Outside the G7, UK output per hour in 2011 was significantly lower than in the Netherlands, Belgium and Ireland, and a little lower than Spain. Since 2007, growth of output per hour has been sluggish in Belgium and the Netherlands, but has recovered sharply in Spain and Ireland.

International comparisons for productivity, with 2007 as a baseline of 100, are shown in Figure 6 (Constant price GDP per hour worked) and Figure 7 (Constant price GDP per worker).

Figure 6: Constant price GDP per hour worked, G7 countries
(Office for National Statistics, 2013a)

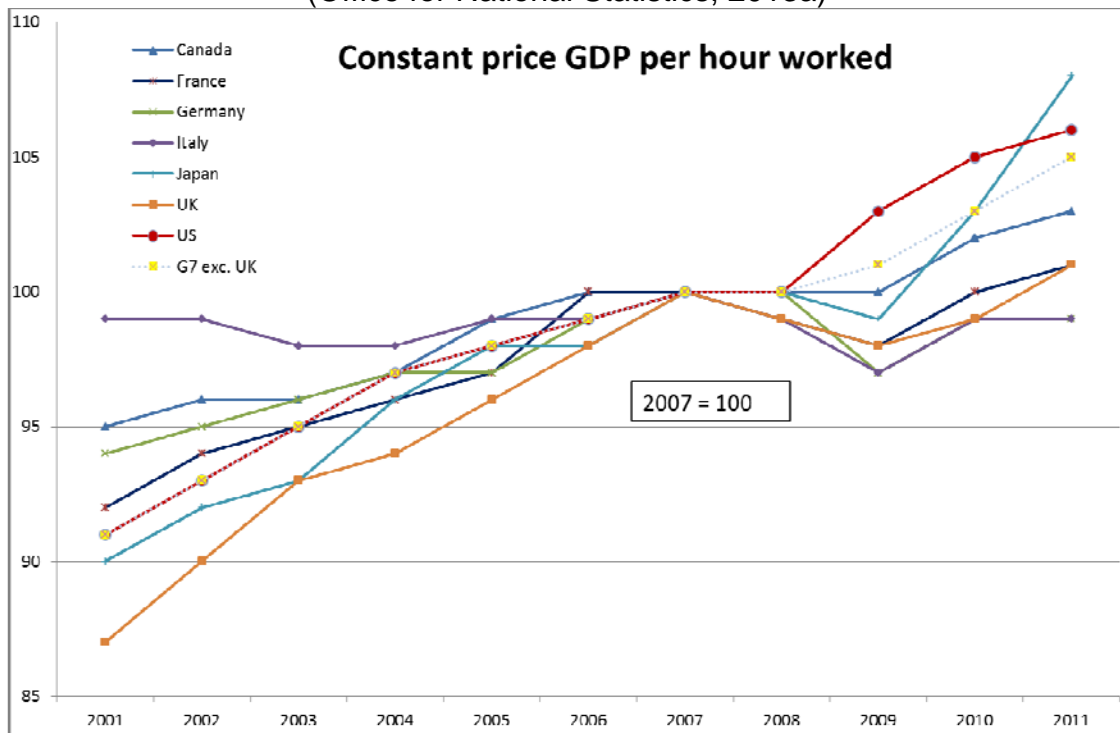
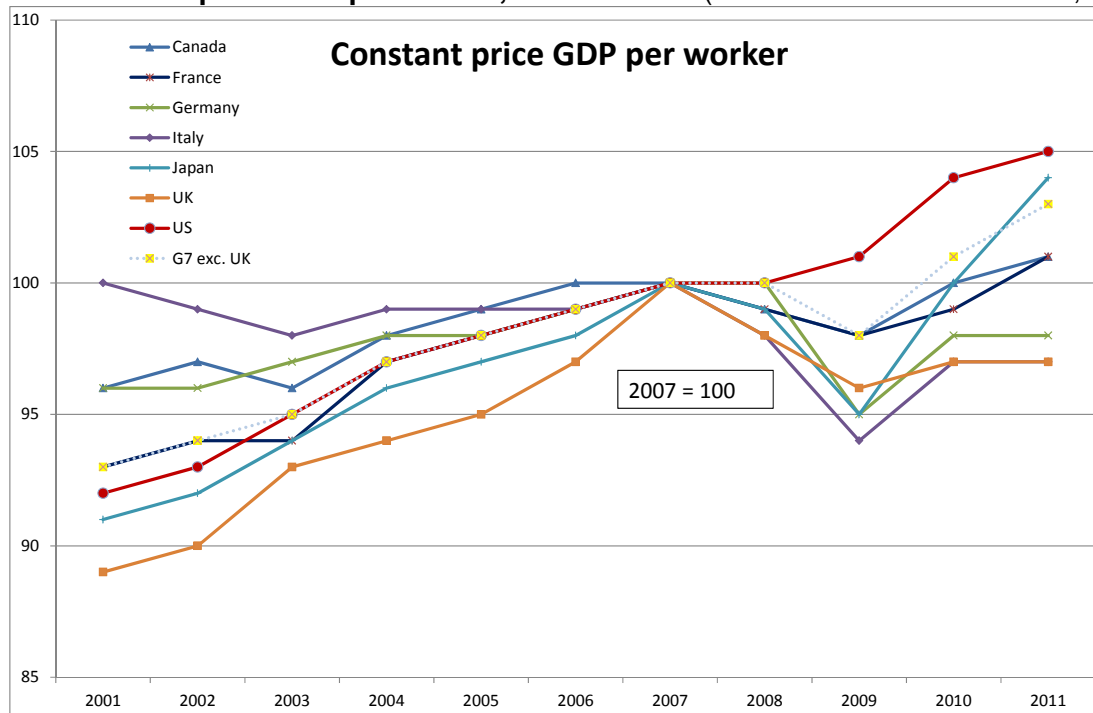


Figure 7: Constant price GDP per worker, G7 countries (Office for National Statistics, 2013a)

Output per hour fell sharply in most G7 countries over the 2008 to 2009 recession, but rebounded equally sharply in the US, Japan and Canada. The recovery in productivity has been much more subdued for the main European economies. For the UK, this contrasts with the pre-recession period when UK productivity growth was comparatively strong.

Education is closely linked to good management. Worker education is also positively correlated with good practice, indicating that implementing modern best practice is more effective when the workforce understands the principles. This is supported by Mannion (2009) who argues that company performance is positively affected by better educated managers and the MBA remains a key component in the USA competitive advantage in management performance. The success of Japan as a manufacturing nation and in particular Toyota Motor Company, is seen as a result of human intellectual energy overcoming adversity (Barker, 2001). In a study of quality and productivity performance, top performing plants, along with their suppliers and customers, showed consistently better process control than did lower performing plants. UK plants did not perform very well in terms of either quality or productivity (Oliver et al., 1996).

UK manufacturing companies' new product introduction projects were generally executed more quickly than those in Japan and North America, but displayed a higher incidence of post-launch problems. Japanese lead times were the longest and Japanese companies performed relatively poorly on measures of development productivity. However, their manufacturing performance was vastly superior to that of Western companies. Early research found that the long-term trend to adopt best practice expressed preference for Japanese production systems as a means of delivering productivity improvements (Pilkington, 1998). More recently, a warning note about Japanese management practices was sounded by AIM (Keizer et al., 2012). Japanese management techniques that were considered to be best practice in the 1980s have become less attractive. In Japan these practices have been adapted to embrace performance pay and greater use of non-regular employment in a move towards a more market oriented and diverse economy, in a move to drive down overall labour costs (Keizer et al., 2012).

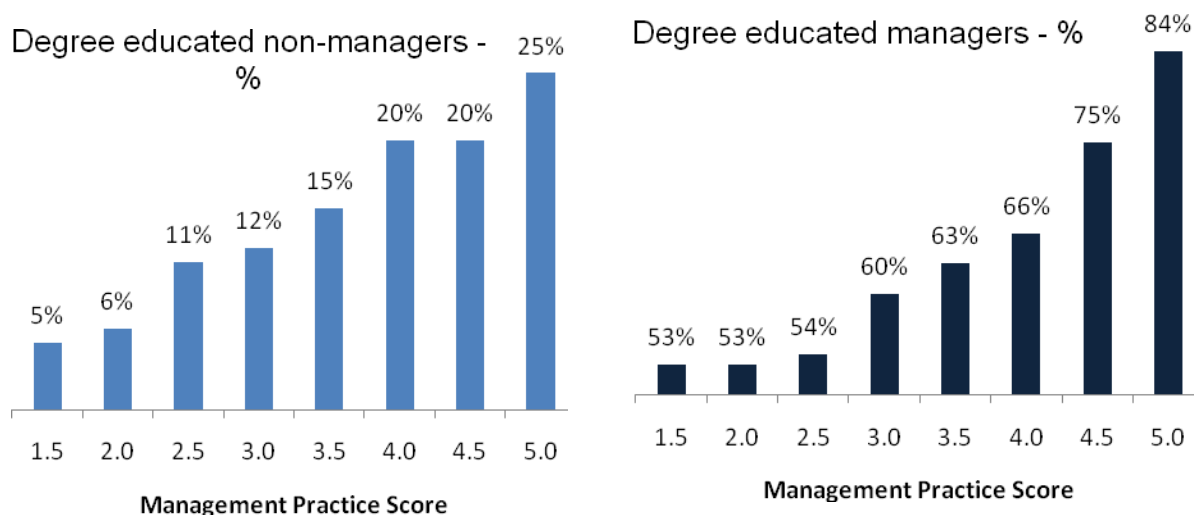
The UK clearly has some way to go to achieve best in class performance across the manufacturing sector. Multinational companies with manufacturing sites in the UK generally make widespread use of best practice. This is most pronounced in the automotive sector. SME businesses struggle to identify and adapt best practice to their own business. However, there is no national or size restriction on adopting best practice to deliver world class performance.

8. Best practice adaptation to accommodate changes in manufacturing

As lean has percolated into ever wider circles of manufacturing operations, it ceases to be about best practice and starts to become part of the basics of doing business (Corbett, 2007). In the same way, TQM is now considered as more routine practice. Six Sigma and its variants are at a crossroads (Goh, 2012). Process focus, pull production, equipment productivity and environmental compatibility currently appear as best practices. Quality management and IT may have been best practice previously, but have lost that status (Bjørge et al., 2005). Some features of best-practice are inappropriate to some companies operating in low volume industries (Maffin and Braiden, 2001). As customer choice grows this may become an issue for UK companies that are effectively operating in very high variety and very low volume environments. For the future, areas such as NPD, e-business, supplier strategy and outsourcing are emerging as possible areas of best practice (Bjørge et al., 2005).

Employee development, engagement and empowerment remains the central and most critically underutilized resource within UK manufacturing companies. Typically this practice is given the least attention when companies attempt to become world class organizations. To achieve this practice a constant loop of dialogue and training is required. However there is a tendency for UK managers to be autocratic and thus inhibit this adoption of best practice (Barker, 2001). Bloom et al (2007) suggest that better management practice is linked to better educated employees and managers. The link between management practice scoring and percentage of degree educated employees is shown in

Figure 8: Correlation of management practice score with level of degree education - (from Bloom et al., 2007)



Markets have become increasingly characterized by turbulence – a situation in which reliance on lean practices is insufficient, and survival requires development of agile competencies. Agile companies pay attention to a wider range of competitive capabilities. Competing simultaneously on multiple competitive capabilities enhances performance more so than a rather narrow focus on cost and quality (Yusuf and Adeleye, 2002). An aging workforce and a loss of key knowledge and practices will require companies to

take steps to manage the transfer of knowledge. Leading companies have methods to capture and manage this knowledge before it is lost. Partnerships are formed with educational institutions that can provide appropriate skills training and ensure the transfer of knowledge to new employees (Champigny, 2006). There is a growing need to deliver customised products to niche markets, placing increasing demand on companies' new product development capabilities. Outsourcing NPD is one option. However, there are few studies of outsourcing NPD (Rundquist and Halila, 2010). Lean is starting to be adopted in new product development (Hines and Packham, 2008; Harris et al., 2010). Applying lean to new product development is still a novel undertaking, but offers significant opportunity for removal of waste from the NPD process (Schulze and Störmer, 2012). With a move towards a knowledge based economy (Wickramasinghe, 2006) competitive advantage will lie with those organizations that are able to deliver quickly and have innovative forms of work organization that deliver high productivity levels. Such organizations will be able to respond quickly and flexibly to customer demand and will have a clear customer focus rather than the traditional marketing approach of product, price, place and promotion (Khan et al., 2007).

SMEs represent the majority of companies across the UK and provide the majority of jobs. To generate growth in manufacturing, SME businesses must start and grow. Culture is a key aspect in determining the success of SME best practice implementation (Oxborrow and Brindley, 2012). However, management practices of small companies are sometimes considered as being informal, short-term, and non-strategic, by comparison with large company practices; which are seen as formal, long-term and strategic. Not all small companies will grow into large companies. Some will not be able to because of the lack of skills of the owner or manager or unforeseen changes in the marketplace; while others will not wish to. This is important when viewing small firms from the perspective of what constitutes best practice. Small firms need to be considered on their own terms (Massey, 2004). For SMEs to grow and be successful, they need to learn, adapt and adopt best practices from world class companies. Such companies encourage the transfer of good practice to their suppliers. However, not all SMEs are in the supply chains of multi-national corporations (de Búrca et al., 2012).

During the 21st century, the capability of best practice transfer will be a core competency of companies and a source of competitive advantage (Luan-Yuan Lu et al., 2010). A potential area of interest in best practice is developing flexibility in manufacturing. There is a growing preference for reducing sources of uncertainty, in addition to responding to it (Boyle and Scherrer-Rathje, 2009). Companies will need to ensure that the required flexibility will be regularly gauged and evaluated as organizational strategy and market uncertainty change in response (Boyle, 2006). Key areas of manufacturing challenge for UK industry were suggested by Thomas et al (2012). These are mapped with appropriate best practice areas that may address the developmental areas for future growth of UK manufacturing in Table 5.

Table 5: Best practice techniques to address nine developmental areas for UK manufacturing (adapted from Thomas et al., 2012)

Manufacturing Challenge	Target	Potential best practice area required to deliver target
Rapid and consistent delivery of new products to the marketplace	Fast response to produce timely and affordable niche products to meet specific customer requirements	Innovation management Agility in supply chains Change management Leadership practices
Develop people competencies to create a move away from “manufacturing” only	Develop capabilities to manufacture “high value” products and services to a global market	Improving productivity in product-service systems
Responsive and precise knowledge management systems	Faster and more accurate decision making within companies	Management education Knowledge management Security of information Advanced analytics
Minimise environmental damage and achieve energy neutral operation	Development of energy efficient local supply systems	Technology adoption Energy management systems Sustainable manufacturing
Rapid enterprise configuration	Ability to reconfigure supply chain and manufacturing capability	Agility in supply chains Change management Leadership practices
Develop innovative products, processes and services	Drive down product lifecycle times and develop more effective NPD and introduction systems	Innovation management Change management Leadership practices
Closer collaboration between industry, universities and colleges.	Collaborative design, research and manufacturing environments.	University/college/industry collaboration Change management Leadership practices
Develop new manufacturing paradigms	Create a flexible, responsive and competitive manufacturing organizations that can continuously evolve and adapt to change	Change management Leadership practices Supply clustering Engagement with universities Application of new technologies
Develop digital networks to enhance the digital economy	Digitally connected supply chains. Novel manufacturing management methods Enhanced learning systems	Application of new technologies Change management Leadership practices Engagement with universities Security of IT systems

9. Best practice for the future

A recent CBI report suggests that if the UK is to continue as a leading economic power in the 21st century, then a growing and diverse manufacturing base must be at its core (Cassley, 2010). Creating a diverse and competitive manufacturing base will require the adoption and adaptation of existing best practices and development of new best practices. From Table 5 the following practice areas are suggested as being able to deliver the desired targets for UK manufacturing in the future. Potential areas of future best practice are:-

9.1 Agility in supply chains and Supply Clusters

In a constantly changing global competitive environment, a company's supply chain agility directly impacts its ability to produce, and deliver innovative products to its customers in a timely and cost effective manner (Swafford et al., 2006). Agility order-winners may change rapidly in a dynamic competitive environment and may need to be constantly updated for each market and customer segment. In such conditions, managers will need to consider the implications of interrelationships among different types of operational flexibilities (Narasimhan and Das, 1999). For the future, the level of agility in the supply chain will determine the efficiency and effectiveness of its collective efforts. It is important that companies become more knowledgeable about the role of logistics capabilities in achieving this agility (Gligor and Holcomb, 2012).

Supply chain clusters are geographic concentrations of three or more companies directly involved in the upstream and downstream flows of products, services, finances and/or information from a source to a customer. They relate to companies in industries related by skills, technologies or common inputs. Clusters offer benefits in, 1. Resource concentration, 2. Reduced supply complexity, 3. Improved relationship between member companies, 4. Increased productivity through faster access to customers, suppliers, and specialized information, and 5. Reduced risk of failure (Kumar, 2011). Supply clusters add value by generating other industrial activities. The self-organization of an industrial cluster can be viewed as a process in which landscape design, positive feedback and boundary constraints co-evolve to generate novel outcomes (He et al., 2011). A key advantage offered by these clusters in the current recessionary economy is that jobs, many of them open to low-skilled workers, are concentrated locally and not "offshorable". Regional and central governments as well as real estate developers are investing in the development of such clusters (Sheffi, 2012).

9.2 Application of new technologies

In sectors that produce high-technology products or are reliant on technology for administrative or manufacturing processes, it is essential to link technologies to markets, in an appropriate manner, in order to increase shareholder value and to build future cash flows. Research and development (R&D) allocations in such industries are very dependent on accurate forecasting of the R&D project's estimated potential contribution to future cash flows; which is related to the project's ability to satisfy current or future customer needs (Bond and Houston, 2003). A fast rate of technological progress, as well as growing markets, or a steeply sloping demand curve, may delay adoption while an increased ability to learn may accelerate it. With multiple technology adoptions, the adoption of any particular technology presents a 'window of opportunity' in which future

investment may be warranted. If this window is missed, then maintaining the older technology becomes more attractive than adoption (Chambers, 2004). Although SMEs can play a significant part as generators of radical new technologies, in areas where the capital cost of innovation is high, the SME contribution is usually small (Rothwell, 1978). Agility in technology adoption may be a best practice in the future. The application of technology to security of information and prevention of unwanted access to company systems will become a growing area of importance (Rees et al., 2011). Techniques that can be adapted across manufacturing industry to ensure this are likely to be adopted as best practice.

Rapid manufacturing - the direct production of finished goods from a rapid prototyping device is more a goal than an every-day reality for industry. The application of 3D printing technologies offers the promise to merge rapid prototyping capabilities with the high-volume throughput of conventional manufacturing. Media attention promotes this as machines capable of printing homes, jet engines and the idea of a factory on a desktop (Vartanian, 2013). However, this technology will change perceptions about economies of scale and about supply chains. When production of components is akin to desktop printing, the concept of production lines and associated tooling requires rethinking. This technology could develop the concept of mass customization as the norm (Smyrlis, 2011). This could substantially alter China's dominance as the mass manufacturing base of the world (D'Aveni, 2013). Proponents of 3D printing believed that these processes may soon lead to the tool-less production of finished goods and the mass production of individually customized products (Bak, 2003). Almost ten years later, although the technology has advanced, the practice has still to find widespread application as a "personal fabrication". However, 3D printing technology may become as ubiquitous as networked computers, with consequences just as significant (Birtchnell and Urry, 2012). Although 3D printing is used primarily to manufacture prototypes, a number of promising applications exist in the production of replacement parts, dental crowns, and artificial limbs, as well as in bridge manufacturing. 3D printing has been compared to such disruptive technologies as digital books and music downloads that enable consumers to order their selections online, allow firms to profitably serve small market segments, and enable companies to operate with little or no unsold finished goods inventory (Berman, 2012).

9.3 Engagement with universities

Collaboration with universities for development of new technologies, new paradigms in manufacturing and adaptation of best practice to suit the changing market, political, social and technological demands will be required. The traditional approach taken by universities and industry as two separate entities may not be suitable to meet this requirement, necessitating different paradigms for university/college/industry collaboration. Collaboration with universities is frequent in knowledge based industries, where research undertaken in partnerships complements, rather than replaces, R&D by collaborating companies. This collaboration improves the performance of innovating firms (Hanel and St-Pierre, 2006; Martin et al., 2010). A methodology that can be utilized by practitioners from both academia and industry to improve the process of collaboration and facilitate more effective transfer of knowledge will deliver more effective collaboration (Philbin, 2008). This provides a route-map for managing such collaborations. Management of this type of collaboration requires tasks such as documenting the history and impact of innovations to the two entities. Although the measurement of innovation imposes an additional workload on management of the collaboration, it must be carried out as failure to do so would result in the loss of significant but hidden benefits, along

with business opportunities and business performance improvements associated with them (Martin et al., 2010).

9.4 Education of manufacturing personnel

Education of both managers and employees is linked to best practice management. A full understanding of the adopted practice and the reasons for its implementation facilitate effective implementation. Economists have traditionally ignored management as a driving factor in explaining differences in productivity (Bloom et al., 2012a). More professional management will deliver higher performance. There is scope to achieve this by adopting and adapting best practice from class leading companies. Bloom et al in their study of transnational management performance (2012b, p 77) suggest that “management makes a difference in shaping national performance”. Educating the workforce at both operator and manager level could become a best practice to be shared across industry. The delivery of this education may be influenced and facilitated by the different paradigms required to encourage industry/college/university engagement. UK mid-size companies’ long term prospects are being restricted by difficulties in finding and retaining skilled employees (Roper and Malshe, 2012). Higher performing companies spend time on training and development of their employees (Prabhu et al., 2000b). Voss et al (1998) suggest that investment in training is a continual pressure for growing manufacturing companies but that it differentiates leaders from the rest. With the growth of the ‘knowledge economy’, and the need to exploit knowledge, management education must improve to equal, if not better, the current best practice.

9.5 NPD and Innovation management

As UK (and other countries’) manufacturing evolves into servitized product offerings and into rapid development and delivery to market of innovative new products, best practices in innovation management and in enabling innovation will enable improved performance amongst UK companies. Allied to this, the development of novel technologies offers opportunities for UK companies to improve their operations to match or exceed current best practice. Many companies lag behind in the area of design and in speed to market for new products (Prabhu et al., 2000b). Companies that outsource NPD activities frequently collaborate with present or possible suppliers. There is a big gap between the best and the others. The best choose to cooperate with universities/institutes, while the remainder have more cooperation with suppliers (Rundquist and Halila, 2010).

9.6 Knowledge management

Organizations that participate in networks tend to have better developed knowledge management systems. The creation of a formalized knowledge management system allows companies to have a higher level of organizational competence across marketing, human resource management and information management (Chaston and Mangles, 2000). As manufacturing becomes more global, companies will need to facilitate innovation and knowledge diffusion along the supply chain to drive improvement in productivity and competitiveness (Gunasekaran and Ngai, 2007). A company’s competitive advantage will flow from its ability to create and exploit new knowledge. Therefore, the need for efficient management of this process effectively will only grow (Franken and Braganza, 2006). The issue of information security is one that is coming to the fore in protecting knowledge assets. This is linked to IT systems and best practice in

the arena of cyber security is likely to become an area of interest to UK manufacturing companies, as a means of ensuring continuing operations and protecting their intellectual capital (Rees et al., 2011).

9.7 Advanced Analytics

Business intelligence and analytics has emerged as a key area for study (Chen et al., 2012). The volume of data in circulation has been increasing at an exponential rate. Analysing large data sets – so-called “big data” – will become a key basis of competition, underpinning new advances in productivity growth, innovation, and consumer surplus. Many pioneering companies are already using big data to create value, and others need to explore how they can do the same if they are to compete. Data has swept into every industry and business function and are now an important factor of production (Manyika et al., 2011). Data is even suggested as a fourth factor in production, along with land, labour and capital (Gobble, 2013). GE considers that cheaper computing power combined with sensor applications are now poised to deliver an era of big data for industry. Jeff Immelt, CEO of GE, suggested that this could help increase worker productivity by 1.5% per year (Fitzgerald, 2013). A key aspect of managing this volume of data is integration of applications (Courtney, 2013). However, Hessman (2013) warns that this will not be easy, suggesting that it will require a new breed of business leader in manufacturing, who is willing to invest capital in big data and analytics.

9.8 Leadership and management practices

Leadership is the basic underpinning of identification, adaptation and adoption of best practice. Leadership will become even more critical to developing and retaining a competitive advantage. Only customers that describe themselves as ‘very satisfied’ are likely to show loyalty characteristics by placing repeat orders (Neely and Adams, 2009). Three simple elements of best practice are suggested as delivering superior performance; 1, Targets: setting long term goals supported by tough but achievable short-term performance benchmarks; 2, Incentives: rewarding high performers with promotions and bonuses whilst retraining or removing underperformers; and 3, Monitoring: rigorous collection and analysis of performance data to identify improvement opportunities (Sadun and Van Reenen, 2012). Management commitment and an unremitting desire to improve are essential for seeking out and adapting best practice to generate competitive advantage. Best practice adoption is most effective when part of a strategic approach. Leadership that develops a strategic approach to seeking, developing and implementing best practice will ensure a competitive advantage for their organization.

Best practice implementation often requires a positive action to change the organizational culture of the company to embed the practice. This is often overlooked, with implementation teams focussing on the mechanistic process and ignoring the engagement and ownership necessary for successful implementation. Training in soft skills in SME businesses is a particular concern about the ability of such companies to adapt and adopt best practice. Managers evaluate alternative solutions, such as new technology or customisation options in product design, based not just on the existing structure and infrastructure, but based on the external environment, current and future capabilities, and the portfolio of best practices available for consideration (da Silveira and Sousa, 2011). Developing a capability in change management, such that the company

can continuously adapt and adopt best practice will ensure a competitive advantage is sustained.

Although noted by Voss et al (1995b) some time ago, the following observations are still valid in 2013, and likely to remain valid in the future. Best practice cannot be adopted as a prescriptive approach. The starting point will depend on each company's current position. However, best practice can be pulled into a company from parents, other companies, suppliers and customers. Best practice can also be pushed through trade associations, government, chambers of commerce and education. The transition of best practice from benchmarking partner to target organization is the most difficult aspect of implementing best practice (Andersen and Camp, 1995). Engaging employees to drive best practice requires that the employees are willing to give according to their abilities. Engaging this willingness to contribute is likely to become a practice that has the potential to enable higher performance levels; becoming best practice in engaging employees and maximising their willingness to give (Grant, 2013). Overcoming inertia may mean taking a more radical solution to achieve best practice adoption across a wide spread of companies. Leadership and change management will be critical best practice skills in achieving this. However, world class operations excellence is not exclusively the domain of any particular country, sector, organization size or company. It remains open to all who wish to lead the adoption practice that will deliver competitive advantage (Cusumano, 2009).

9.9 Productivity in product-service systems

Lean is well established in traditional manufacturing. It is beginning to diffuse into service operations with similar benefits to manufacturing. As manufacturing businesses adopt a product-service system offering, the use of lean can deliver competitive advantage. However, lean in this area is not just a copy of lean in manufacturing. The adoption of lean needs further adaptation to the delivery of servitized product offerings (Alsmadi et al., 2012). Different mechanisms will need to be developed to ensure the same relentless elimination of waste in the service side as is realisable in the product side. Within the automotive industry, suppliers who are not able or not willing to become full service systems suppliers or to offer a servitized product may be relegated to the second tier or cease to exist (Clifton, 2001). For example, as product-service systems develop and grow, MRO becomes more important and a contributor to competitive advantage. The global MRO market is predicted to grow as more businesses adopt servitized product approaches. A recent ADS report notes that UK aerospace has a £20 billion turnover and a 17% share of the global market (ADS, 2012). Aerospace in the UK is number one in Europe and number two in the world, behind the US. UK companies currently generate £2 billion revenue in aircraft maintenance and repair. With 70 % of aerospace being exported, this adds to a positive trade balance. Lucintel predict that the UK aerospace industry will grow at 6.8% per year over the next five years. MRO operations could benefit from the adoption of lean and cellular manufacturing approaches to drive productivity improvements. Mathaisel (2005) developed a lean enterprise architecture (LEA) specifically for enterprise-wide transformation in the MRO industry, suggesting that cellular design manufacture is described as 'very useful to the transformation of an industrial enterprise' (2005 p4). Benefits in cost, throughput speed and reliability have been reported by applying lean engineering practice through cellular units in commercial MRO environments (Reopel, 2012). Developing best practice in MRO operations could deliver the opportunity for growth in this developing sector.

9.10 Sustainable manufacturing systems

Manufacturing systems that exist in harmony with the environment will be more likely to remain sustainable. For the future, energy and water will become a scarcer resource, and husbanding of supplies and management of consumption will be critical to maintaining a competitive advantage. This is likely to emerge from being a desirable practice to one that is essential to create a competitive advantage. It is not just the company that must be considered. The future of the eco system, and therefore that of future generations, is at stake. It is not enough to be successful in business, it is becoming imperative to safeguard the environment, safety and welfare of those alive today and prepare for those yet to come (Gunasekaran and Spalanzani, 2012). Issues of sustainability are likely to encourage the growth of niche or “craft” producers who can take advantage of market proximity to obviate environmental impact of long supply chains. Sustainable manufacturing is a growing area. Although there is some work on sustainability in the product design, supply chain, production technology and waste avoidance, there is much scope for development of best practice (Despeisse et al., 2012).

10. Potential benefit from adopting best practice principles in the short-to-medium and long term

UK productivity in 2011, shown in Figure 5, was above that of Japan, slightly lower than Canada and Italy, and well behind the remaining G7 countries (Office for National Statistics, 2013a). The question is, by adapting best practice across UK manufacturing, how long would that change take to deliver the anticipated benefits? Assuming a long-term coordinated initiative is introduced to drive UK productivity to world-class levels, an interim target of 10% improvement by 2020 and a final target improvement of 30% by 2050 could be established.

In 2011 UK manufacturers' sales were £338 billion (Office for National Statistics, 2012). A 10 % improvement in GDP per hour worked could add over £33 billion to this figure for the same hours worked. Correspondingly, a 30% improvement in GDP per hour worked could add over £100 billion to UK manufacturers' sales. The UK is equally able to implement best practice as the best in class, the USA (Cusumano, 2009; Mannion, 2009). With a long tail of less well managed businesses, there is likely to be more scope to drive productivity improvement amongst these companies than amongst the class leaders. To achieve world class levels of productivity across UK manufacturing, a holistic approach is likely to be required to encourage and facilitate adoption of best practice across all manufacturing sectors and with particular emphasis on smaller businesses.

11. Policy implications for UK Government

Unlike the USA, evidence suggests that many UK SME businesses are not well managed. Encouragement and support for underperforming SME businesses could address this issue. Encouraging the creation and growth of SME businesses would encourage competition, which in turn encourages adoption of best practice. A consequence of this must be a willingness to allow businesses that do not implement best practice to fail, thus improving the overall performance of the group. Concurrent with this the growth of mid-size companies must be addressed. UK mid-sized companies have not grown at the same rate, since 2009, as equivalent companies in Germany – the German “Mittelstand”. If their growth had matched that of Germany, an additional 240,000 jobs and £35 billion additional turnover could have been created (Roper and Malshe, 2012).

Government's role in improving the nation's competitiveness is in acting as a catalyst and challenger for industry to innovate and upgrade (Porter, 1990). Government can provide support and resources by encouraging best practice through education, trade associations, and chambers of commerce (de Búrca et al., 2012). The following areas could be considered as routes to encourage the adoption of best practice in UK manufacturing.

1. Long term encouragement and incentives to improve productivity through best practice adoption. Facilitation to set up a national, rather than regional or independent, approach to finding and adopting best practice.
2. Encouragement of competition in the manufacturing SME area, including support for manufacturing SMEs to start and to grow into mid-size companies.
3. Specific action to manage the long tail of poorly managed SME businesses that pull down the overall management effectiveness of UK manufacturing.
4. Specific encouragement for UK mid-sized companies to improve productivity and grow.
5. Facilitation and support for improving the standard of education of workforce and management in finding, adapting and adopting best practice. Education specifically focused on developing and implementing best practice in manufacturing, and incentivising companies to undertake this education would support this.
6. Encouragement for industry and colleges/universities to collaborate on developing a common perspective on finding and adopting best practice, and in improving knowledge and competencies of those in UK manufacturing. Management of knowledge is a key aspect to adopting best practice.
7. The UK Government is considered to be less interventionist than many European countries. However, where it has played an active role the benefits have been significant; for example in aerospace and defence (PricewaterhouseCoopers, 2009). Frequent and high-level interaction between Government and Industry is a key enabler of retaining a competitive manufacturing sector. Germany is a best practice case in this respect. The growth of UK manufacturing is too important and too critical to future UK prosperity to be left to natural selection. UK manufacturing has the capability to develop world-class practices, but will need support in the form of direction, guidance and coordination that is most effectively delivered by a national body.

12. Conclusion

This study evaluated best practice in manufacturing. A number of practices are currently considered effective in improving business performance, but as in the past, future best practices are likely to change. New practices that focus on the soft skills, on agility and adaptation are likely to come to the fore in being recognised as best practice in manufacturing. That is not to say current best practice will fade. The adaptation of existing best practices is likely to lead to an evolution of these as they are applied to new areas of manufacturing, such as product service systems. Within the UK, best practice is most evident within automotive and aerospace companies, followed by plastics and general engineering. It is more prevalent in foreign owned and multinational businesses with UK sites than in domestic companies; and within companies that value and promote education for their employees. There are pockets of individual best practice in some sectors, but UK industry lacks a homogeneous adoption. SME businesses lag behind larger organizations, but all have the opportunity and ability to adopt best practice if the leadership and strategic intent is present. Key aspects to successful implementation of best practice are a strategic commitment, top management and workforce engagement, communication and adequate skills amongst the employees. There is no one prescriptive solution, but each company must assess what is best for them and implement accordingly.

The UK has some way to go to achieve best in class performance across the manufacturing sector. However, there is no national or size restriction on adopting best practice to deliver world class performance. Ten potential areas of future best practice are suggested. There is no reason why UK manufacturing cannot improve productivity by identifying and adopting best practices from global manufacturing. The USA stands out as the leader in best management practice, but matching and bettering this is open to any country. Achieving best practice operation and leading levels of productivity is realisable within UK manufacturing, but will require a holistic perspective and specific support to enable this.

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