THE FUTURE OF MANUFACTURING

MAXIMUM FLEXIBILITY AT COMPETITIVE PRICES

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SCM World

Author

Pierfrancesco Manenti

Vice President, Research, SCM World

Pierfrancesco leads the research practice for manufacturing & production operations and design for supply chain & product lifecycle management at SCM World. He provides insights, learning & development and advisory support to leading global manufacturers and service providers on the key challenges and trends affecting manufacturing industries, including automotive, machinery, aerospace, fashion & apparel, CPG and hi-tech.

Front cover photo courtesy of ABB

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CONTENTS

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EXECUTIVE SUMMARY

This report is intended to answer a number of questions that are currently keeping manufacturers awake at night. Where is manufacturing headed in terms of offering maximum flexibility at low costs? How will manufacturing footprint strategies change as a consequence? What are the key operational principles that manufacturers will have to embrace in the coming years? What role does human labour play in this manufacturing future and how does this affect training and skill development issues at the plant level?

To deep dive into the future of manufacturing, SCM World recently conducted a joint survey with the not-for-profit industry association, MESA International. This was designed to take the pulse of manufacturing industry and highlight the strategies and priorities of manufacturing leaders and their teams with regards to the importance of production, the factory of the future and the role of people on the plant floor.

We also interviewed a number of SCM World community members and other manufacturers to validate the findings of the research and bring in practical examples to complement the survey data.

Among the findings of this report:

- Manufacturers of the future will have to move away from today's exclusive focus on efficiency and pay closer attention to fulfilling customer needs.
- The era of offshoring factories to remote low-cost locations is drawing to a close. Labour cost advantages are diminishing in importance as the primary driver of new manufacturing location decisions.
- Effectively responding to customer demand for speed and personalisation will need to become a major capability for manufacturers.
- Just as the digital economy is revolutionising every aspect of life and business, so the factory of the future will be digitally infused, providing tightly interconnected information and production flows.
- Plant-floor workers' knowledge and their ability to learn quickly and adapt to new technologies will represent an essential source of competitiveness for manufacturers in the future.

INTRODUCTION

Over the past 20 years, globalisation has dramatically changed the face of manufacturing. The rise of offshoring opportunities enabled developed-world manufacturers to use low-cost labour countries – notably China – as a workshop. Labour arbitrage looked like an easy way to gain operational cost reduction and cut total supply chain costs. With the assumption that lower-cost labour would suffice to make the business case, many manufacturers simply closed down their own home-based production facilities.

As a result, the world's most developed countries lost a significant share of their manufacturing jobs, particularly those dull, repetitive jobs that couldn't be efficiently automated. In the United States, for example, during the period 1978 to 2007 manufacturing job losses equated to about 30% of the total number, according to the US Bureau of Labor Statistics.

Today, with rising labour costs in many emerging economies, the development of a number of game-changing plant-floor technologies and a marketplace that is fundamentally different than it was 20 years ago, many companies are revisiting their manufacturing strategies.

MANUFACTURING RENAISSANCE

In his recent book *Make It in America*, Andrew Liveris, Chairman and CEO of The Dow Chemical Company, offers a passionate argument on the role of the manufacturing sector for the wealth of an economy. "Manufacturing matters – more than ever before," he writes. "Not all sectors are created equal. Manufacturing can create jobs and wealth and growth to a degree that the service sector can't match... the key to economic growth is taking something of lesser value and transforming it into something of greater value. That's what manufacturing does."[1]

Recent research by the Massachusetts Institute of Technology and Harvard University confirms that manufacturing is immensely important to the prosperity of nations. Over 70% of income variations across 128 countries during the past 60 years can be explained by differences in manufactured product exports.[2]

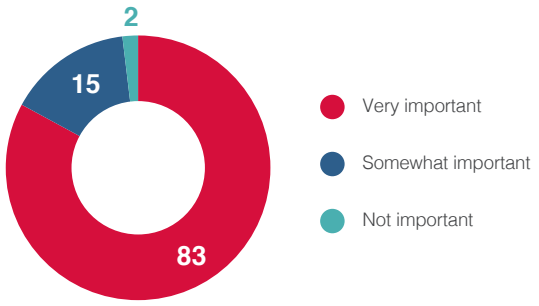
With this in mind, many governments today have a better understanding that an economy based on services alone cannot survive in the longer run. They are once again looking at manufacturing as a critical source of wealth and a sector to invest in for future prosperity. Our survey data confirms that manufacturing industry is entering a new period of renaissance, with more than 80% of respondents saying that manufacturing is very important to their countries' economic competitiveness.

THE CONSUMERISATION OF MANUFACTURING

With greater attention from both governments and manufacturers, production is back under the spotlight. However, companies find themselves in a

1 | Manufacturing is king

Importance of manufacturing to your home country's economic competitiveness five years from now



Source: SCM World-MESA International survey

% of respondents
n=158

marketplace that is profoundly different to the one that existed before globalisation took off. The extensive availability and rapid diffusion of information via social networks has completely changed how consumers are purchasing goods. At the end of the value chain, consumers are well informed about products, prices and market trends. They compare, select and discard multiple products with just a tap on their tablets. Consumers are also increasingly impatient, reluctant to wait around for the next season's products to be made in remote Chinese factories.

Consumers' changing purchasing behaviour is not only having an impact on consumer product industries, as expected; it is also dictating the speed at which the entire manufacturing value chain has to operate. So much so that B2B (business-to-business) trading is now often called B2B2C (business-to-business-to-consumer), indicating the growing importance for manufacturers to take care of their customers' customers, right down to the end consumer.

Companies such as Amazon are driving the "consumerisation" of manufacturing. Consumers have the freedom to buy any product they want. And they no longer need to go to a physical store to get it, but can order it online and have it delivered to their home in a day or two. This is dramatically changing consumers' purchasing expectations, which in turn is driving a need for more personalisation and regionalisation in manufacturing strategies.

Consumers increasingly demand highly customised products, perfectly fitting their specific needs and at no higher price than a comparable standard, mass-produced item. Nike, for example, is tapping into this opportunity through its NIKEiD initiative, which enables an individual to customise their trainers' performance and style, and then purchase them online. At the same time, mobile and app-based services such as Uber and Airbnb are giving consumers greater variety and personalisation, while disrupting industries that have remained largely unchanged for decades.

MAKE TO INDIVIDUAL

Meeting the demand for speed and personalisation will be a major capability for leading manufacturing companies of the future. Responding to speed with speed will help manufacturers to meet fickle, fast-changing demand and enable them to tap opportunities from niche markets and even anticipate buying preferences before they translate into actual purchases.

Manufacturers along the entire value chain need to learn how to become faster in fulfilling specific customer needs before competitors do. They need to understand demand trends more deeply, introduce new products more rapidly and meet specific customer fulfilment needs in multiple global markets.

The pace at which manufacturers need to change their footprints to accommodate evolving consumer expectations is driven by the speed in product innovation. Manufacturers need to innovate their production processes at the same rate of technology innovation – a pace never seen before in a production environment. And they will have to become more agile in adapting to new technologies and making their factories more flexible to accommodate shorter lead times.

These changes are heading towards a future that can be called "make to individual" – a modern fulfilment approach where customers are served with a single, specifically tailored, customised and innovative product, made on demand.

THE THIRD INDUSTRIAL REVOLUTION

The first industrial revolution began in the late 18th century with the mechanisation of the textile industry, representing the transition from hand production methods to machines. More than 100 years later, in 1913, Henry Ford revolutionised manufacturing by adopting the moving assembly line that dramatically increased productivity. Ford's River Rouge assembly plant was a monument to his mass production principle, with iron ore (from Ford mines) and rubber (from Ford plantations) coming into the factory, and all-black Model Ts (because of their quicker drying time) rolling off the line and into a growing, ready market.

At the time of Henry Ford, production constraints drove manufacturing industry and standard products were pushed to the market. A century on, consumers are in the driving seat: they have far more choice and can dictate to manufacturers what products they really want. Nevertheless, many companies today still base their manufacturing strategies on Henry Ford's mass production principles, extended with a massive dose of productivity based on low-cost country sourcing, lean methodologies and factory automation.

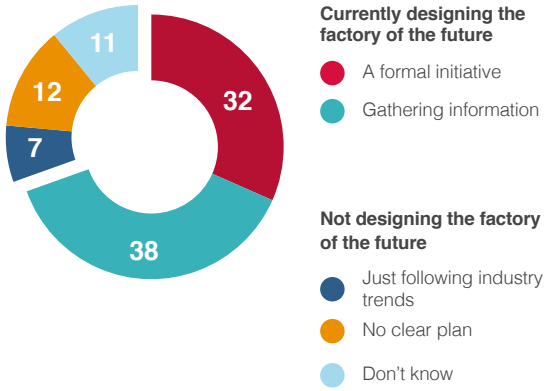
While manufacturers champion productivity, many consumers are interested in speed and customisation – not just cost. This mismatch between demand and supply is the most critical challenge in manufacturing industry today. Making products when the customer wants them, while also making them profitably, is no easy task. Many companies find themselves in a situation where they are managing a network of offshored factories with long lead times, insufficient visibility and too little ease of manoeuvre to flexibly adapt to a rapidly changing marketplace.

In order to adapt, manufacturers will have to develop a make-to-individual fulfilment approach that will have a significant impact on today's manufacturing strategies. This formidable marketplace change is driving the industry towards a phase of profound rethinking, whose consequences will define this new industrial revolution.

THE FACTORY OF THE FUTURE

On their way towards the third industrial revolution, manufacturers are rediscovering the importance of making things. After many years of "oblivion", manufacturing organisations have come to realise that production execution is a fundamental element of their supply chain. The factory plant floor is where a company's supply chain strategy becomes reality. It is where customer orders are fulfilled and it is where customer satisfaction – or dissatisfaction – originates.

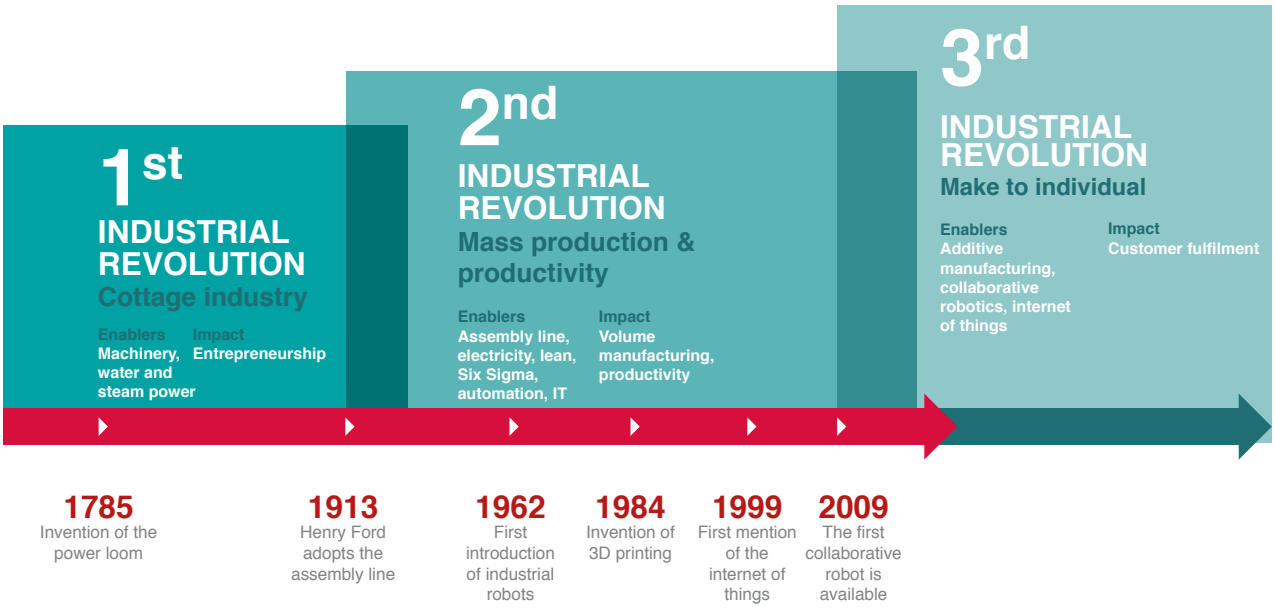
2 | Progress towards the factory of the future



Source: SCM World-MESA International survey

% of respondents
n=174

3 | The three industrial revolutions



Disconnected, unco-ordinated manufacturing facilities are inevitably the bottleneck of supply chain management. Regardless of any supply chain strategy improvement and increasing sensitivity to market demand signals, all will be for nothing if manufacturing capabilities cannot keep pace with a healthy dose of flexibility.

Manufacturers are going back to basics, to their manufacturing roots. They are putting a renewed premium on production knowledge driven by the need to protect and enhance their products and production technologies. They are realising that a direct involvement in production fosters innovation and improves customer service. Our survey data shows that 70% of manufacturers are currently looking at how factories will be organised and managed in the future. Almost one-third have a formal initiative under way, with executive management directly involved and funding it.

THE SHIFT FROM CAPACITY TO CAPABILITY

The traditional approach to manufacturing – attached to the stronghold of efficient production plants and permanent cost-cutting initiatives – is no longer adequate as a response to the market challenges manufacturers are beginning to face. Manufacturers of the future will have to move away from today's exclusive focus on efficiency, which tends to be inward-looking and risks distracting attention from the essential goal of fulfilling customer needs. What's the point of having super-efficient factories if they can't meet customer needs for speed, innovation and personalisation? Efficiency will continue to be important in the future, of course, but meeting customer fulfilment needs with higher levels of flexibility will be more important still.

Manufacturers of the future will have to link customer requirements directly to production. They will need to focus on their production *capability* to fulfil customer needs rather than just making sure their production *capacity* is fulfilled.

In our extensive research for this report, we have identified three essential capabilities that manufacturers of the future will need to improve customer fulfilment:

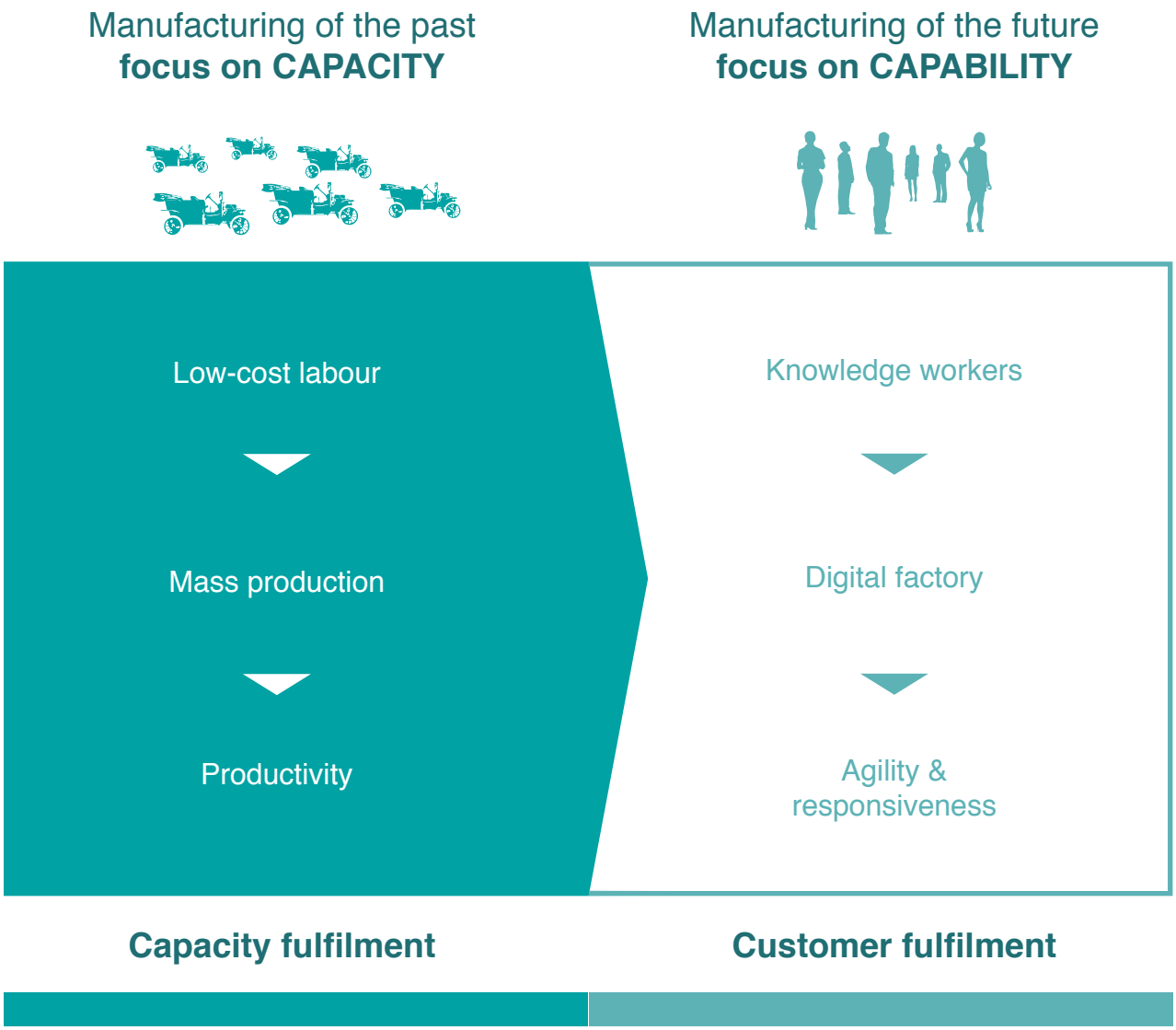
- **Agility and responsiveness** is the quintessential capability. To develop it, manufacturers will have to implement a number of manufacturing footprint principles: proximity to demand, postponement of variability and centres of excellence. In addition to these principles, manufacturers will have to transform their production facilities in digital factories and will have to extend and leverage the skills of their people on the plant floor.

- **Digital factory** represents the pervasive use of IT (hardware, software, applications and telecommunications) on the plant floor, as part of the digital economy that is revolutionising every aspect of business. With the digital factory – where traditional boundaries among machinery, automation, robotics, operations technology and information technology blur – manufacturers digitally plan, simulate and execute production processes across the entire lifecycle of both products and production facilities.

- **Knowledge workers** will represent the essential base upon which manufacturers of the future will quickly learn, adapt and leverage new technologies supporting the digital factory. Knowledge workers will also provide the degree of flexibility and decision-making capability that will be required alongside the digital factory to deal effectively with increasing market demand volatility.

These capabilities align to the three fundamental aspects of organisation, technology and process that will form the essential framework for the third industrial revolution. In the following sections, we explore these three fundamental capabilities in more detail.

4 | From capacity to capability



COMPANY SPOTLIGHT

Harley-Davidson shifts from capacity to capability

As the global economic slump hit in 2008, Harley-Davidson lost 40% of its business. The company embarked on a thorough enterprise transformation process aimed at shifting it from a traditional manufacturing company into an agile and responsive organisation. The centrepiece of this transformation is the realisation of its factory of the future based on a profound transformation of the York Vehicle Operations facility, its largest assembly operation, accounting for more than 60% of the company's motorcycles.

Established in 1973, the York factory was designed on Henry Ford's mass production principles and was highly inefficient and extremely inflexible. In 2008, the facility consisted of 41 buildings added one after another, year after year. Each motorcycle model was assembled on a dedicated assembly line. The process flow was heavily constrained by the physical space and shape of the buildings.

Harley-Davidson tried to implement lean manufacturing several times through the years, without achieving substantial benefits. Although its employees felt a strong pride for working for such an iconic brand, they felt underserved and undervalued, and as a result didn't fully embrace lean principles.

The transformation of the York facility was based on the simple need to reduce complexity and organise the factory through lean principles, driven by what adds value to the customer.

Among the key activities implemented:

- **Factory layout** – 41 buildings have been consolidated into just two, with all production taking place in one of these. This facilitated the creation of a better production flow.
- **From multiple physical chains to one digital chain** – Harley-Davidson got rid of the cumbersome physical assembly line – where motorcycles rigidly move along a predetermined path – to a digital chain where they move on flexible AGVs (automated guide vehicles) that are driven by planning needs and software. This adds a greater degree of flexibility and real-time rescheduling capabilities.
- **Production planning** – The planning cycle has moved from a 21-day fixed plan to a six-hour horizon. This has greatly impacted inventory on hand, which is now just three hours compared with 8-10 days in the past.
- **Robotics** – Low-added-value and repetitive activities are fully automated. Robots weld parts together, paint chassis and produce fenders more precisely and faster.
- **Fewer people, higher skills** – The new factory has about half the number of employees it had previously, as a result of automation, outsourcing, lean manufacturing and the use of flexible workers during seasonal periods. At the same time, workers are more engaged and skilled to manage a highly digital factory.
- **Plant-floor visibility** – Every step of production is tracked and incorporated into a real-time performance management system available on large screens around the plant, on desktops and on mobile devices. Management has full visibility of plant-floor performance.

The transformation of Harley-Davidson's York factory is a great example of a company shifting from capacity to capability through the development of a digital factory – supported by the use of SAP software – which led to more agility and responsiveness, and the elevation of plant workers to knowledge workers. This transformation drove down costs by 7%, increased response times and met customer expectations more successfully, resulting in a 19% increase in the company's net margin.[3]

AGILITY & RESPONSIVENESS

Agility relates to the ability of a manufacturer to respond to changes in the marketplace and unforeseen events efficiently and effectively. Responsiveness relates to the speed at which a company can make decisions to meet customer needs. The combination of the two determines how it is able to embrace change and complexity: understand it, adapt to it and leverage it – all very rapidly.

As shown in Figure 5, manufacturers are set to change the way they measure the performance of their factories over the next five years. If today a successful factory is measured by its ability to keep operational costs down and its reliability – or the ability to perform tasks as expected – in five years' time costs will give way to agility as the undisputed metric to measure plant-floor success.

To get a sense of where manufacturers will focus their efforts in the next few years, we calculated a "normalised growth index" for five key metrics, so as to be able to compare today's value with that in five years' time. This analysis reveals that the two metrics that will decrease in importance over the next five years are exactly those that manufacturers are primarily focused on today: costs and reliability. Going forward, however, those that will gain in importance are, above all, agility – with 3.7% normalised baseline growth – and, to a lesser extent, responsiveness, with 2.8% normalised baseline growth.

This shift in metrics greatly mirrors the profound transformation the industry is moving through along its journey towards the third industrial revolution. Future manufacturers will not simply measure performance in terms of productivity but more and more will invest to increase their plant-floor flexibility as they transition from capacity to capability.

There are three major principles that will support manufacturers in becoming more agile and responsive:

- **Proximity to demand** enables shorter lead times and speed in customer fulfilment.
- **Postponement of variability** enables late product configuration to meet specific customer needs, at an acceptable cost.
- **Centres of excellence** enables agility and responsiveness through higher levels of standardisation among different factories.

5 | Manufacturing agility and responsiveness

Importance of five key SCOR-based performance attributes for manufacturing operations

	Today		In 5 years		Normalised growth index	
Reliability	✓	4.30	✓	4.51	▼	-3.0%
Responsiveness	✗	3.95	!	4.39	▲	2.8%
Agility events	!	4.08	✓	4.57	▲	3.7%
Costs	✓	4.26	!	4.39	▼	-4.9%
Asset	✗	3.83	✗	4.25	▲	2.0%

PROXIMITY TO DEMAND

The era of offshoring factories to remote low-cost countries is drawing to a close. With the skyrocketing increase in labour costs in many traditional low-cost countries like China and the availability of more efficient automation systems, the business case for offshored manufacturing is less obvious today than it was previously.

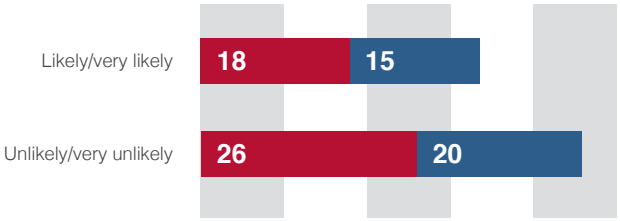
The majority of respondents to our survey consider it unlikely that their companies will increase their sourcing from lower labour cost countries over the next few years (see Figure 6). The share of these companies is 13 percentage points higher than those who say they are likely to increase offshoring.

Modern manufacturers are realising that an offshoring decision based on low-cost labour advantages may not necessarily lead to total supply chain cost reduction. Most importantly, it will not lead to effective customer fulfilment, particularly when the factory location is remote from where demand must be fulfilled. Modern manufacturers understand that there are several other factors they have to consider when taking offshoring decisions, and which they have often overlooked in the past. For example, lead-time considerations, sustainability implications, higher working capital and supply chain disruptions to name just a few.

As the opportunity of low-cost country sourcing or offshoring is diminishing, many companies are planning to bring manufacturing back to their home countries – a movement often called "reshoring". An SCM World survey last year found that more than half of executives (57%) planned to reshore at least some of their manufacturing.[4]

6 | The end of an era?

Likelihood of low labour cost sourcing increasing in next few years



Source: SCM World-MESA International survey

% of respondents
n=176

The approach to manufacturing footprint strategy has changed dramatically over the past few years, from one driven by lowering manufacturing costs to one driven by improving customer fulfilment through agility and responsiveness. Labour cost advantages are growing less and less important as a driver to select a new location for manufacturing, while the reshoring movement is driven by the need to get closer to demand and set up a more regional manufacturing footprint. Companies such as Ford, General Electric and Intel are planning to open new factories or to move production back to the US because they want to be closer to their customers and be able to respond more quickly to changes in demand.

For this reason, China continues to be a magnet for new manufacturing capacity. As shown in an SCM World report last year[5], China is the top country for manufacturers to add new capacity in the next few years. It has moved from being a low-cost country to recently overtaking the US as the biggest economy in the world, and is doing it by redefining the future of manufacturing. The same report helps us to understand the most compelling reasons driving manufacturers to add production capacity in different global regions:

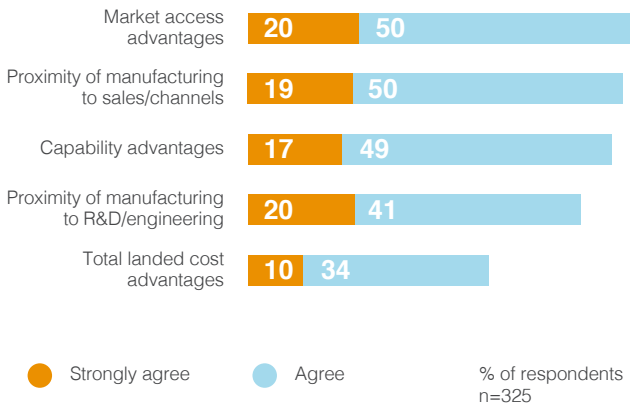
- **Market access.** Opening or moving a plant in a certain new location means overcoming trading barriers and working with local partners for easier market access. It also means a better understanding of local demand and customer preferences.

- **Proximity of manufacturing to sales/channels**. The advantage of being closer to demand is the ability to shorten lead times and to fulfil customer needs faster and more effectively. It also enables manufacturers to customise and localise products efficiently.

- **Capability.** In the fulfilment of customer needs, capability means having the ability to produce a vast range of products in a single factory with a higher degree of flexibility to meet variable demand. In a world where demand is impossible to accurately forecast, capability is the key for success.

- **Proximity of manufacturing to R&D/engineering**. Some products are so complex or personalised that it helps to have the engineers who developed them nearer to the plant floor.

7 | Reasons to add production capacity in particular regions



Source: SCM World report, *Manufacturing Footprints: Getting to Plant X*

Lego Group has announced plans to build and operate its own factory in China to supply products for the growing Asian market. Construction is expected to begin this year. "It is our strategy to have production close to our core markets in order to secure short lead-time and world-class service to our customers and consumers, and it has proven a successful strategy," says Bali Padda, Lego's Chief Operating Officer. "Having full control of the production process is essential to deliver products of a consistent high quality and safety and in harmony with our values. In addition, by placing a manufacturing site in the region we reduce our environmental impact as we will reduce the need for transporting products from Europe to be sold in Asia."[6]

POSTPONEMENT OF VARIABILITY

Postponement of variability – or build to order as it is often called in automotive, industrial and hi-tech manufacturing industries – is the practice of customising finished products once customer orders are in. With postponement, manufacturers can respond faster to individual orders because products are built on demand by combining a modular platform with a number of standard components that qualify the features of the products, according to the specific requests of customers.

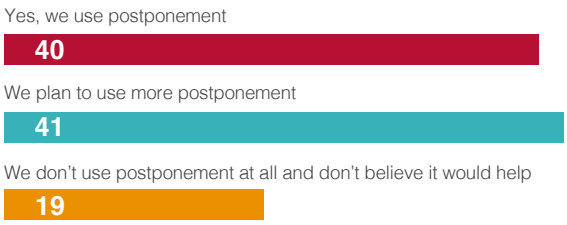
Different industries have different definitions of what a platform is. In automotive, for example, a typical platform is the chassis, while engines are components that qualify features of the final product. In chemicals, a platform can be the recipe for a bulk product, while additives that create the final speciality chemical are the components. In mass-produced consumer products, postponement may relate to different types of packaging that serve different customers and sales channels.

Our survey data reveals that 39% of companies already have a postponement of variability strategy in place. More than 40% are planning to use more postponement of variability in future, particularly in industries like consumer products, food & beverages and healthcare & pharmaceuticals that are relatively new to this strategy. One in three of these companies has a cross-functional initiative in place to create more modular products, which in turn would enable them to use postponement. The remaining two-thirds would like to use more postponement but today most of their products are neither modular nor designed for postponement.

Using postponement strategies, companies such as BMW, Caterpillar and Dell have been able to cut inventory carrying costs, avoid rebates on finished products that aren't selling, and reduce the risks of obsolescence. Postponement of variability is at the centre of HP's "supply chain pipes" strategy. This modular approach to supply chain management enables a flexible composition of elements such as factories or distribution centres that better fit each type of product. The core of each "pipe" is the postponement capability that is optimally allocated along the supply chain: closer to factories for higher-volume standard products; closer to demand for low-volume, configurable products. Postponement is the centrepiece of HP's supply chain flexibility and has enabled the company to reduce inventory by 45% and achieve $1 billion in annual savings.

8 | Postponement of variability

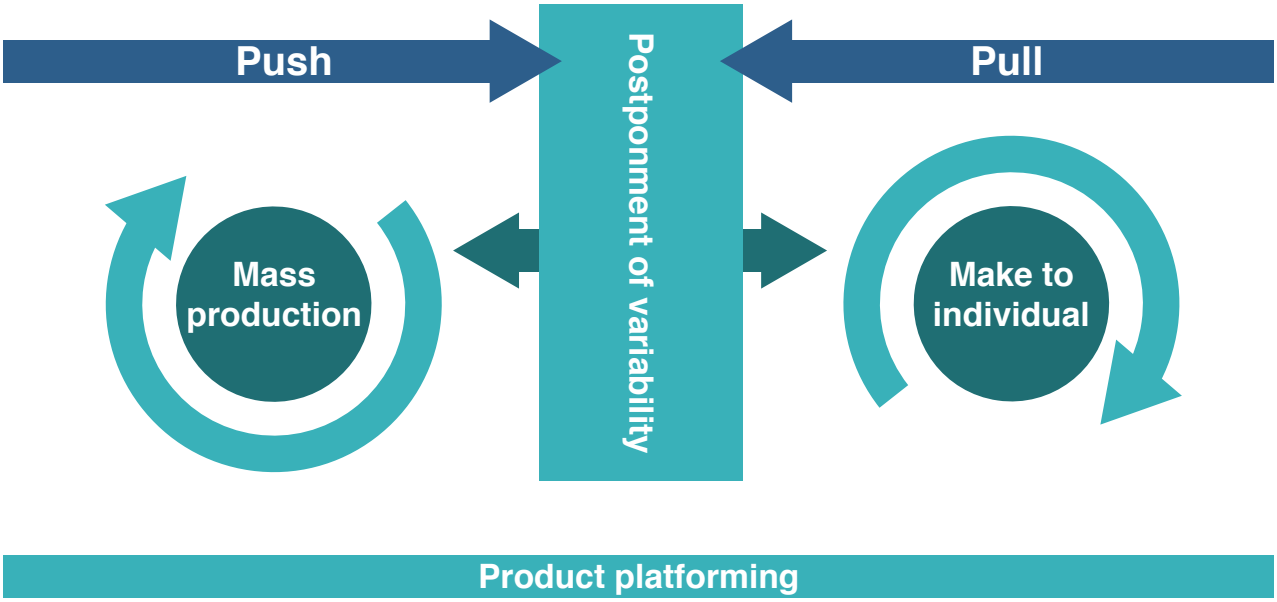
Extent to which companies use this strategy today



Source: SCM World-MESA International survey

% of respondents
n=174

9 | A push-pull strategy using postponement of variability and product platforming



Postponement has also been key to digital camera maker GoPro's dramatic growth (see company spotlight).

Postponement is not just for hi-tech or industrial products. Classically mass-produced consumer products can also be subjected to the same approach. Coca-Cola, for example, has launched "Freestyle" vending machines that allow individual consumers to mix branded soda products – the product platform – with a number of additional flavours. Unilever recently created a number of "Magnum Pleasure Stores" where consumers can create customised ice creams by picking a selection of coatings, toppings and decorations to be added to a base ice cream, which is the product platform that is mass produced.

The key enabler of Zara's fast-fashion capability is its postponement strategy. Zara is able to track fashion trends continually and produce "skeleton" designs for new items that are not final but are specified enough to allow purchases of long-lead-time materials such as fabric and trim packages. These basic designs are then finalised with input from stores that reflect current demand trends, but are constrained within the bounds of whatever materials are on-hand.

Product platforming is an essential support to postponement. It enables the segmentation of production processes in modular manufacturing steps such that the company can choose where and when to take each step. Manufacturers can specialise and diversify their factory networks and implement a push-pull strategy where some factories produce modular platforms and common components, while others focus on the postponement of finished products on demand (Figure 9).

With this factory diversification strategy, companies can use large, efficient but less flexible plants to satisfy the higher-volume demand for standard modules and components, and smaller, potentially higher cost but more flexible plants to meet low-volume demand and provide additional capacity if demand changes.

The combination of postponement and proximity to demand enables manufacturers to bring customisation closer to the customer through a network of small factories dedicated to postponement and final configuration.

Our recent CSCO 2014 survey found that nearly a quarter of manufacturers will adopt this push-pull strategy over the next five years, by focusing on producing modular platforms and critical parts in-house, while final configuration will be made on demand by a network of third-party factories or retailers closer to customers.

With an ability to postpone final configuration, manufacturers greatly increase their agility to respond to specific customer needs without building up a risky inventory of finished products. At the same time they

can cut order to delivery times because platforms and common components have been produced or procured already and are available for final configuration.

With this model, production or sourcing lead times for the platform and common components are not added up to order to delivery time. Customers get the benefits of rapid delivery of a customised product, while manufacturers reduce both the risk of obsolescence for finished products and the costs of on-hand inventory. Postponement also has a significant impact on supply chain and logistics, since moving platforms or common components near to the customer before final configuration is cheaper than moving finished products.

COMPANY SPOTLIGHT

Postponement provides flexibility for growth-focused GoPro

GoPro produces a range of wearable cameras that allow consumers to capture live images taken during activities like surfing, driving or parachuting. Founded in 2004, the company has doubled its revenue almost every year and now has annual sales of almost $1 billion.

Until 2011, GoPro's supply chain was very simple and appropriate for a start-up. All products were made in China and shipped to a distribution centre in California. The company's size and growth prospects, however, made its supply chain structure unsustainable. As a result, GoPro embarked on a profound supply chain transformation:

- Three regional distribution centres with postponement capabilities were created in Singapore, the Netherlands and California.
- Supply chains for packaging and cameras were decoupled to better fit different product characteristics: packaging is low value and bulky, while cameras are high value and small.
- Bulk cameras are manufactured in China and shipped to regional DCs via airfreight. Full packaging – without the camera – are assembly kitted for each camera type in China and shipped via ocean freight to regional DCs.
- Product "mix" decisions are taken in the regions closer to demand, and the regional DCs make the final configuration.

This supply chain transformation drew significant benefits both in terms of cost reduction and increased flexibility. Although the cost of regional postponement is higher than it would be in China, total supply chain costs went down because of reduced transportation and inventory costs.

Postponement capabilities also dramatically increased GoPro's flexibility in managing unforeseen events and disruptions. In October 2013, just after the launch of its new waterproof camera, GoPro discovered a failure in the seal. The company had to stop the entire supply chain for two weeks to re-engineer its seal. Postponement was key to a fast supply chain turnaround. A rework process was engineered in the DCs by adding one extra step along the assembly line to substitute the seal.

GoPro has realised several benefits from postponement, including:

- Camera freight costs reduction by 75%
- Inventory costs lowered by 11%
- Rework, firmware re-flash, camera functional testing, custom product bundles and local language SKUs enabled in regions
- Pack-out capabilities to mitigate risk in case of disaster[7]

CENTRES OF EXCELLENCE

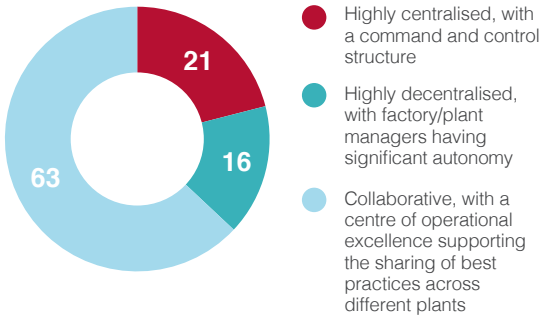
A centre of excellence (CoE) – often called a "council" or "programme management office"– refers to a team acting as a shared service for a larger organisation. CoEs provide best practices, research, support and/or training for issues that are relevant across functions and regions. In manufacturing, it often refers to factories that are centres of excellence in making certain types of products. Manufacturing CoEs, or "centres of operational excellence", typically drive innovation in production processes, technologies and IT systems, implement the initiatives that arise as a result and facilitate best-practice dissemination across the network of factories and suppliers' facilities.

As pointed out earlier in this report, many companies are finding themselves in the daunting situation of managing an extremely complex, globally dispersed network of production facilities and warehouses, with many being outsourced to third parties or offshored in remote locations. In most cases, the network is made up of diversified facilities in terms of production technologies and processes. Each factory often acts in isolation and the metrics being used to measure performance are often not consistent across different facilities, making visibility of network performance difficult and flexibility almost impossible.

According to our survey, implementing CoEs appears to be the best way for manufacturers to manage their footprint complexity. As shown in Figure 10, in future the majority of companies will eschew both highly centralised and decentralised operational structures. Instead, they will adopt a collaborative approach based on the notion of a CoE supporting the sharing of best practices across different plants and through a greater emphasis on involving plant-floor employees in decision-making.

10 | Centres of excellence

Expectations about how factory networks will be managed in the next five years and beyond



Source: SCM World-MESA International survey

% of respondents
n=174

In recent years, companies such as Unilever, Volvo and Campbell Soup have successfully implemented CoEs to overcome the challenges of their extremely complex and global manufacturing footprints. Through implementing these structures they achieved an ability to harmonise, supervise, and co-ordinate execution activities across their entire networks. An interesting example of successful CoE implementation comes from engine maker Cummins, which created an ad-hoc organisation to break silos and leveraged a common manufacturing execution system as a repository of best practices gathered across all factories.

Flextronics, a global contract manufacturer that offers design, manufacturing, distribution and aftermarket services to other manufacturers, uses a CoE as a way to continuously innovate its manufacturing capabilities, particularly in the light of customers' requests. Flextronics' innovation services and product introduction operations in Milpitas, California, act as a CoE to enable its clients and prospects to go from concept to product delivery quickly. Some of the technology available includes 3D metal and plastic printers, X-ray and test equipment, CNC machining, as well as capabilities in anodising, advanced automation, radio frequency and microelectronics packaging.

Establishing CoEs is an essential way to achieve operational excellence in today's complex manufacturing environment, because they provide better control over the network with a broad functional footprint and a tight level of integration among factories, suppliers' facilities, plant-floor data and devices, and corporate processes.

Manufacturing CoEs' operational activities follow a continuous improvement approach geared around the ability to identify opportunities for process and technology improvement, implement standard processes, KPIs and IT systems, and analyse common KPIs to gain consistent visibility across the network of factories, suppliers' facilities and warehouses.

CoEs provide an ability to gain a uniform and standardised operational environment for all plants

globally, which avoids duplication of process, production technologies and plant-floor IT systems. The benefits of standardisation are many, but the ability to consistently measure and compare performance across a network of facilities and the supply chain is particularly advantageous. This is the most critical initiative manufacturers are planning to undertake over the next five years, according to our data.

With high levels of standardisation across factories, manufacturers can better orchestrate the network to respond to demand fulfilment needs, significantly improving agility and responsiveness. For example, CoEs provide an ability to quickly offload production volumes from one factory to another without incurring the months of product industrialisation normally required to accommodate a new product in a non-standard production environment.

Standardisation also guarantees the same level of quality and customer fulfilment across the network of factories, which improves market consistency and customer satisfaction. Last but not least, standardisation enables a reduction in IT costs and automation maintenance.

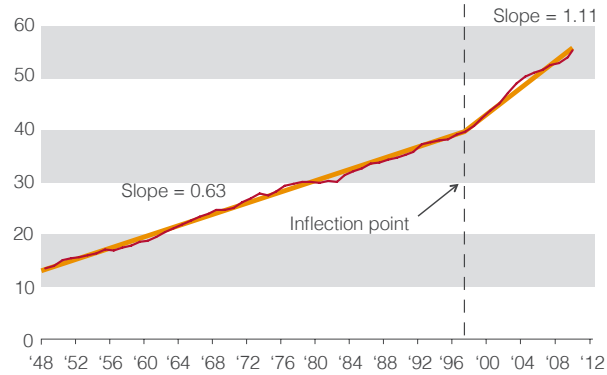
11 | Centre of excellence key functions

THE DIGITAL FACTORY

Underpinning the future of manufacturing is the extraordinary advancement in information, communication and operation technologies. With the digital economy revolutionising every aspect of life and business, the factory of the future will be digitally infused, providing tightly interconnected information and production flows.

The evolution towards the digital factory started in the late 1970s, as manufacturers began equipping their factories with automation technologies with the aim of creating perfectly efficient plants able to minimise costs and maximise yields. This factory automation revolution was later followed by the IT revolution, which provided manufacturers with back-office process automation. The combined productivity gained through technology in manufacturing is massive. The slopes of the productivity growth line in Figure 12 show a decisive inflection point in US productivity in around 1996. This happens to be the same moment that commercially available internet access became a reality with Netscape. As technology created an opportunity to go beyond the four walls of an enterprise and integrate the supply chain, productivity accelerated.

12 | Productivity of the US economy
Output/hour (US$, 1948-2010)



Source: US Bureau of Labor Statistics, Office of Productivity and Technology, March 21, 2012

Going forward, the trend of manufacturers shifting from capacity to capability will open up new opportunities to utilise plant-floor technologies. In the near future, competitive differentiation in manufacturing won't come only from productivity improvements or lower costs, but also from the agility and responsiveness of reconfigurable manufacturing capabilities. If productivity was the essential driver for automation and IT adoption in the past, in the future agility and responsiveness will be the driver for plant-floor technology investments.

In the digital factory, smart machines will collaborate with each other, the material flow will be visible in real-time through intelligent analytics, and teams of knowledge workers will orchestrate the entire process. The digital factory will comprise all aspects of manufacturing, from plant operations to the supply chain, and enable virtual tracking of capital assets, processes and resources throughout the entire product lifecycle.

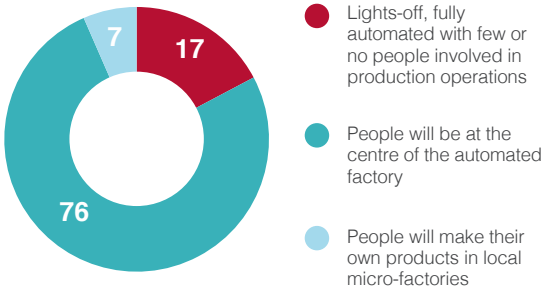
The emergence of a number of new, game-changing technologies – from collaborative robotics to the internet of things, and from big data analytics to additive manufacturing and 3D printers – is expected to support manufacturers through this dramatic change. (The impact of these technologies on manufacturing and the opportunities they provide will be analysed in more detail in a separate SCM World report to be published next month.)

PEOPLE, IT AND AUTOMATION

The factory of the future will be digital, but it won't be lights-off, fully automated with few or no people involved in production operations. Indeed, more than three-quarters of our survey respondents believe that people will be at the centre of the automated factory of the future, because they provide the degree of flexibility and decision-making capabilities required to deal with demanding customers.

13 | Power to the people

Expectations of how the factory of the future will look in five years and beyond



Source: SCM World-MESA International survey

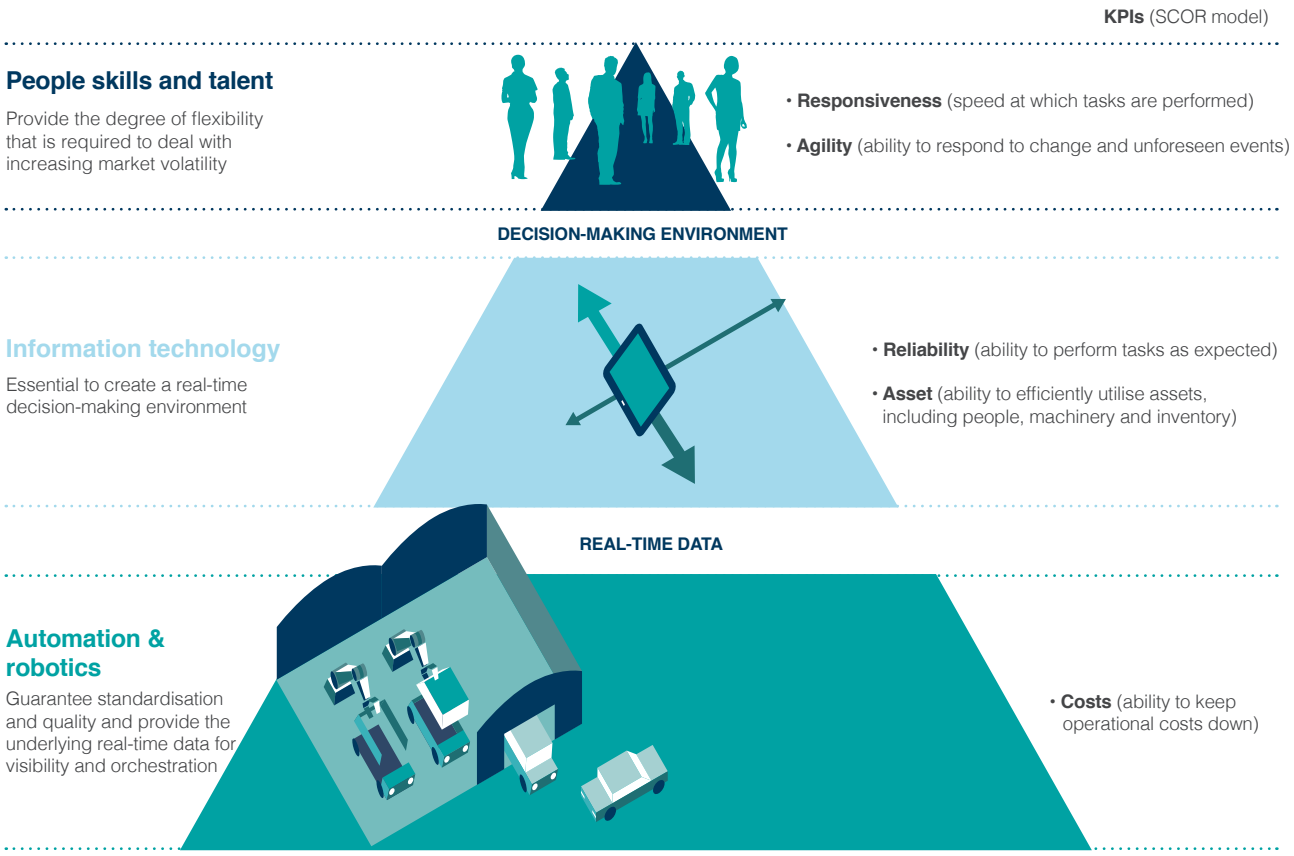
% of respondents
n=168

The digital factory will be based on three fundamental, interconnected elements:

- **People skills and talent.** Knowledge workers will supervise the digital factory, leveraging their skills and a flexible attitude. They will need timely information that allows them to take informed decisions. Gaining more visibility of plant-floor performance emerges from our survey as the most critical initiative that manufacturers are expected to undertake over the next few years.
- **Information technology.** The decision-making environment is represented on one side by IT systems that governs production execution – from SCADA (supervisory control and data acquisition) systems to MES (manufacturing execution systems) software – and on the other by IT that is employed in the design and planning of production systems, including simulation and 3D visualisation.
- **Automation and robotics.** There is no way to create visibility of plant-floor performance without access to the real-time information gathered through factory automation. Without it, decision making is likely to be manual and error-prone, with workers guessing rather than taking action on the basis of hard evidence.

The three layers of the digital factory will impact plant-floor performance in different ways, with people (supported by IT and automation) driving the most relevant KPIs of agility and responsiveness (see Figure 14).

14 | The three layers of the digital factory



Automation with a human touch at ABB

ABB is a multinational conglomerate with operations in around 100 countries. Its core businesses are in power and automation technologies. ABB's Dalmine factory near Milan, Italy is one of the most important production plants of medium voltage apparatus in the world and is the home of the "ABB Dalmine Lean Way".

What makes this plant unique is the perfect blend of automation and skilled people. The lean principle that guides this factory is called *"jidoka"*, one of the foundational elements of the Toyota Production System that is often defined as "automation with a human touch". Applying this principle means using automation when it makes sense and making sure its performance is constantly monitored by operators. *Jidoka* implies that a full "lights out" automated factory with no people involved does not work properly, unless there is a balanced mix of automation and supervisory functions.

Following *jidoka*, each machine or robot at the ABB Dalmine factory is able to identify abnormal situations and can stop the line automatically by calling the attention of operators. This ensures that no defective products are produced and unsafe conditions are avoided. Since equipment automatically stops, a single operator can visually monitor and efficiently control more equipment at the same time. People are essential here as they can investigate the root causes of the anomaly, identify a solution or a countermeasure, and fix the problem.

People at the ABB factory are knowledge workers able to operate in a very hi-tech manufacturing environment. This has allowed plant managers to leverage workers' talents and skills to deliver flexibility, creativity and better decision making.

Discerning automation

The ABB Dalmine factory is certainly highly automated. However, automation has not been implemented just for technology's sake. All dull and repetitive tasks are automated, as are those considered risky for health and safety reasons. The same applies for those requiring high precision, standard or repetitive quality and automatic data storage. Only high-volume assembly lines are automated, while low-volume lines draw greater benefits from manual assembly.

Among the most interesting automated areas:

- AGVs (automatic guided vehicles), triggered by signals from the assembly line, pick from the warehouse all necessary parts to assemble a single customer order on a kit, which is then moved just-in-time to the line.
- Robots are used to perform visual quality tests at the end of the line. These tests are conducted through automatic vision capabilities that enable the robot to compare the physical product with its 3D digital image.
- One multi-axis robot is used in a flexible production cell that is able to perform a number of different pre-assembly operations such as fastening, screwing or tooling on a range of different product frames.

With the fundamental supervision of knowledge workers, the ABB Dalmine plant has been able to take full advantage of automation and robotics. The benefits of *jidoka* are many: in four years the factory improved order-to-delivery time by nearly 5% and increased efficiency by more than 12%. But perhaps the most interesting result is that *jidoka* enabled ABB to bring back production from a low-cost country to high-cost Italy.

KNOWLEDGE WORKERS

The manufacturing renaissance discussed in this report is not about the return of an "old-style" manufacturing sector based on low-wage, low-skilled labour and mass production. With the advancements in technologies supporting the digital factory, manufacturing is becoming more and more productive and the number of people directly involved in performing manual tasks in the production environment is declining. The days of huge manufacturing plants with vast armies of workers might soon be over.

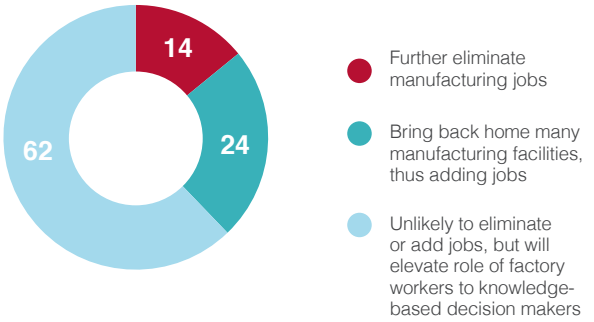
Nevertheless, as this report has shown, more than three-quarters of manufacturers believe that people will be at the centre of the automated factory of the future. We are on the verge of a new era for the manufacturing sector, where plant-floor workers' skills will be at the heart of the digital factory as an essential capability to fulfil customer needs.

Additional survey data further supports this finding. More than 60% of respondents believe that the adoption of modern plant-floor technologies such as advanced robotics and additive manufacturing is unlikely to either eliminate jobs or increase them; rather, these technologies will elevate the role of factory workers from mundane task implementers to knowledge-based decision makers.

With this in mind, more manufacturers will bring production facilities back to their home countries, creating new skilled jobs in manufacturing in the process. Many dull, repetitive tasks will become obsolete, including many assembly operations, thanks to the rapid advancement of collaborative robotics having more dexterous capabilities. Future jobs in manufacturing will be related to the supervision and control of automated facilities from an engineering, logistics, quality automation, IT and customer fulfilment perspective.

15 | The employment effect

Expected impact of advanced robotics and 3D printing on jobs in five years' time



Source: SCM World-MESA International survey

% of respondents
n=156

SPEED OF KNOWLEDGE

Modern manufacturers clearly recognise the essential role of plant-floor workers and realise that as products, systems and the business environment becomes more complex and technology intensive they will need to develop new skills. This will lead to a trend of perceiving plant-floor workers' knowledge as capital to invest in.

However, the rate of human knowledge acquisition is progressively being exceeded by the rate at which such knowledge becomes irrelevant. In a 2012 report, the World Economic Forum concluded that the speed at which knowledge is acquired will determine future manufacturing competition. "In a world where change is speeding up, knowledge stocks depreciate in value at an accelerating rate," the WEF argues. "In this new world, companies… need to become more adept at tapping into a broader range of more diverse knowledge flows so that they can refresh their knowledge stocks at a faster and faster rate." [8]

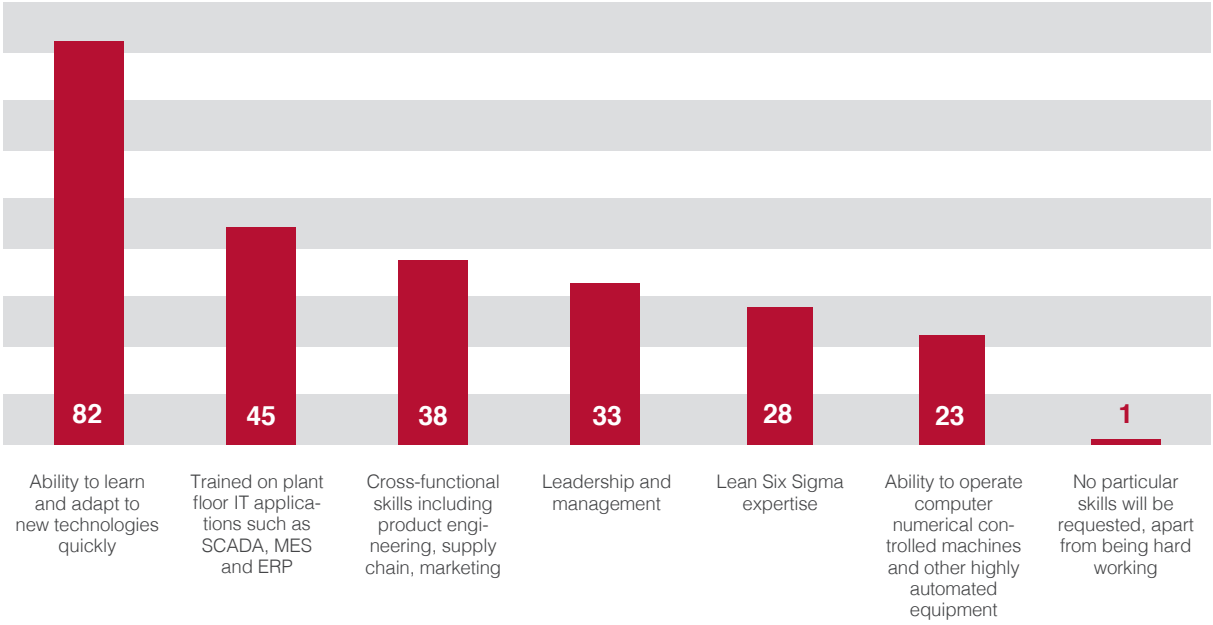
It comes as no surprise, therefore, to find that more than 80% of manufacturers in our survey believe that the advancement of the digital factory will require plant-floor workers to develop an ability to learn and adapt to new technologies much faster than they do today.

Almost half of manufacturers believe that being trained on plant-floor IT applications such as SCADA, MES, and ERP will be an important capability. A third or more also see leadership and management and cross-functional skills such as product engineering, supply chain and marketing as emerging skills for plant-floor workers. These new skills will overtake more traditional skills such as lean Six Sigma expertise or the ability to operate computer numerical controlled (CNC) machines and other highly automated equipment.

The transformation of manufacturing from a low-wage, low-skills labour industry to a knowledge worker sector is also changing the perception of it as an attractive place to work. More than 70% of respondents to our survey say they would recommend a career in manufacturing to family members. However, resistance to change and scepticism about new technologies remains in manufacturing environments today. Current plant-floor workers threaten to become a bottleneck in achieving the level of skills required for the digital factory. As a consequence, engaging these workers in continued training about new technology developments is an essential task for modern manufacturers.

16 | Future skills required of plant-floor workers

Most important skills in five years' time



Source: SCM World-MESA International survey

% of respondents
n=159

CONCLUSIONS & RECOMMENDATIONS

Like all revolutions, the future of manufacturing will be disruptive. Along the way, manufacturers are rediscovering the importance of making things. But the third industrial revolution won't see the return of "old-style" manufacturing based on low-wage, low-skilled labour and mass production. The emergence of several game-changing technologies – from collaborative robotics to the internet of things, and from big data analytics to additive manufacturing and 3D printing – will make the plant floor more efficient and raise the role of factory workers from mundane task operators to knowledge-based decision makers. The manufacturing plant floor will once again become a cool place to work and will attract a younger generation of talented workers who are proud to be making goods.

Tomorrow's factories will be very different from today's. The game will be about different levels of agility, responsiveness and innovation, with the fundamental support of technology and people's skills. Knowledge workers will be at the centre of the factory of the future as they provide the level of flexibility that is required to fulfil customer demands for highly personalised products.

On the journey to the third industrial revolution, manufacturers will have to implement a number of changes in their manufacturing strategies that can be summarised as follows:

- **Shift from capacity to capability.** Manufacturers of the future will have to move away from today's exclusive focus on efficiency towards a closer attention to customer fulfilment needs. Efficiency will still be important in the future, of course, but meeting customer needs with higher levels of flexibility will be much more so. Making factories agile and responsive will be the quintessential capability. This shift will require the adoption of principles such as proximity to demand, postponement of variability and centres of excellence, as well as a massive change in mindset.

- **From offshoring to proximity to demand.** The era of offshoring factories to remote low-cost locations is over. Labour cost advantages are growing less and less important as the exclusive driver to select a new location for manufacturing. The most compelling reasons to add new production capacity in global regions are market access advantages, proximity of manufacturing to sales/channels, capability to fulfil demand, and proximity to R&D/engineering.

- **Postponement of variability.** Responding effectively to consumers' demand for speed and personalisation will be a major capability for manufacturers in the future – something we call the "consumerisation of manufacturing". By developing an ability to postpone the final configuration of products, manufacturers will greatly increase their agility to respond to specific customer needs. With postponement, the customer gets the benefits of rapid delivery of a customised product, while manufacturers reduce the risk of obsolescence for finished products and the costs of on-hand inventory. Implementing postponement requires manufacturers to develop a high degree of product platforming, which is one of the most compelling barriers to implementing postponement of variability.

- **Centres of excellence.** Many companies are finding themselves in the daunting situation of managing an extremely complex, globally dispersed network of production facilities, with many being outsourced or offshored in remote locations. Creating centres of excellence offers the ability to standardise operational environments, avoiding duplications of manufacturing processes, production technologies, plant-floor IT systems and performance metrics. With a high level of standardisation across factories, manufacturers can better orchestrate the network to respond to customer fulfilment needs, significantly improving agility and responsiveness.

- **Digital factory.** As the digital economy is revolutionising every aspect of life and business, so the factory of the future will be digitally infused, providing tightly interconnected information and production flows. The digital factory – where production flexibility will blend with performance and productivity – will represent the peak of the perfect integration of manufacturing breakthroughs, technology innovation and knowledge workers that will shine in contrast to the dark and dirty image of manufacturing in the past.

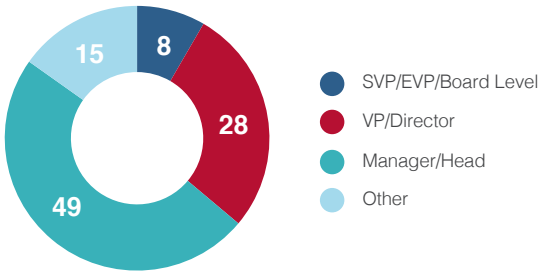
- **Knowledge workers.** People's knowledge and their ability to learn quickly and adapt to new technologies will represent the essential source of competitiveness for future manufacturers. Workers' decision-making capabilities will enable faster reaction to exceptions, higher planning reliability, and flexibility in responding to customer fulfilment needs, and will be an essential enabler for agility and responsiveness.

ABOUT THE RESEARCH

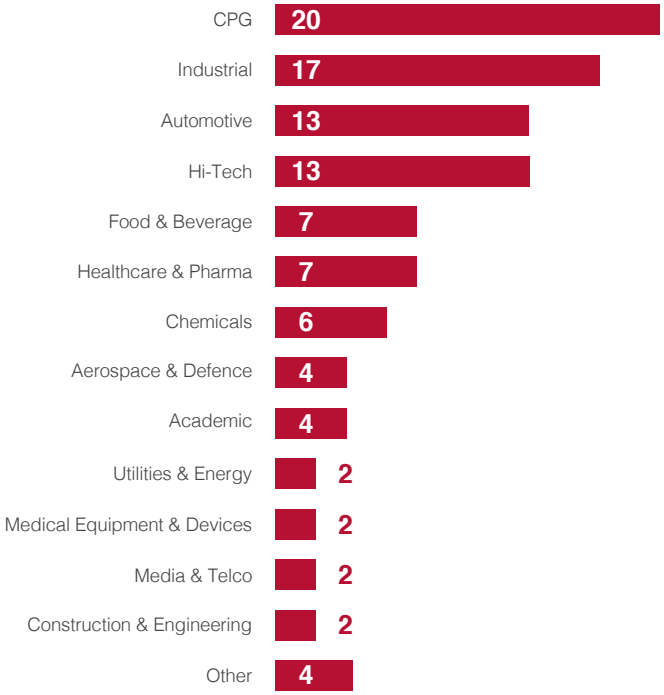
Invitations to complete an online survey were sent to corporate members of both SCM World and MESA International, along with other manufacturing and supply chain practitioners from July to September 2014. In total, 214 completed responses were received during this period, but for the purposes of this report those respondents from the professional services and software sectors were excluded from the analysis. This left a total of 191 completed surveys.

Key demographics (all figures % of respondents):

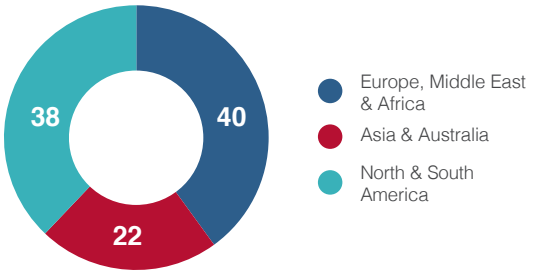
Job level



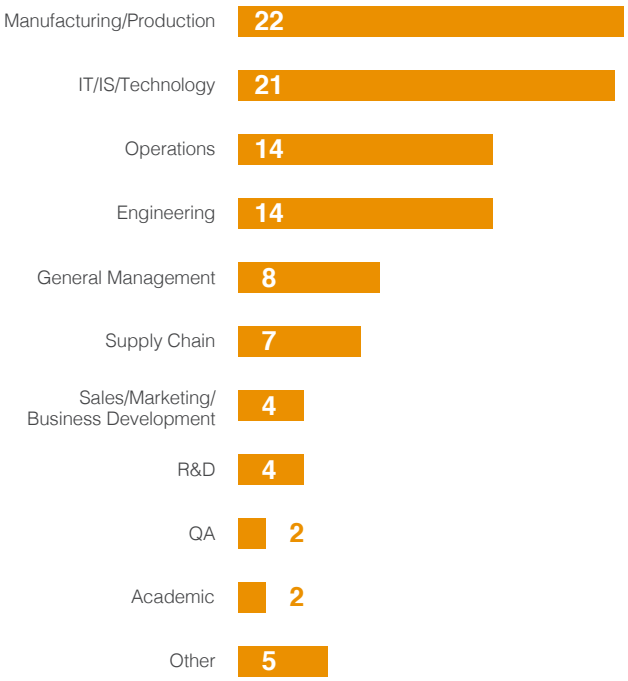
Industry sector



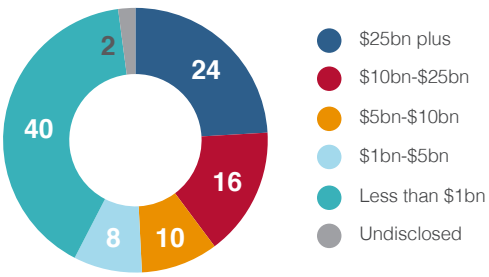
Geographic location



Job function



Company size



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[4] Kevin O'Marah and Dr Hau Lee, *Manufacturing Footprints: Getting to Plant X*, SCM World, April 2013.

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[7] For more details, see the SCM World webinar "GoPro supply chain evolution – regional postponement strategy", Scot Briggs, GoPro, 1 May 2014.

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ABOUT SCM WORLD

SCM World is the supply chain talent development partner for the world's leading companies, empowering professionals with the capability, commitment and confidence to drive greater positive impact on business performance and help solve three of the world's fundamental challenges: health, hunger and environmental sustainability.

The SCM World community accelerates collective learning and performance by harnessing the knowledge of the most forward-thinking supply chain practitioners, shared through industry-leading research, best-practice exchanges, peer networking and events. Over 150 companies participate in and contribute to the SCM World community, including P&G, Unilever, Nestlé, Samsung, Lenovo, Cisco, Merck, Caterpillar, Nike, Walgreens, Jaguar Land Rover, Raytheon, Chevron, Shell and BASF.

For more information about our research programme, contact:

Geraint John
Senior Vice President,Research
+44 (0) 20 3747 6200
geraint.john@scmworld.com

2 London Bridge, London
SE1 9RA, United Kingdom

+44 (0) 20 3747 6200
www.scmworld.com

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