NewStatesman

Manufacturing steps up

Contributions from

Vince Cable | Chris White | Terry Morgan

in association with

CATAPULT High Value Manufacturing

SIEMENS

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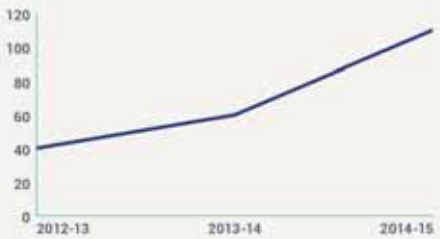
GM

Increasing the value of manufacturing

The High Value Manufacturing (HVM) Catapult promotes and supports technological innovation in high-value manufacturing companies of all sizes. Since its inception in 2011, the HVM Catapult has achieved impressive performance and impact figures. Here are some of its headline numbers at a glance.

£m Collaborative R&D funding accessed by SMEs



HVM Catapult economic impact to date

Total value of HVM Catapult assets

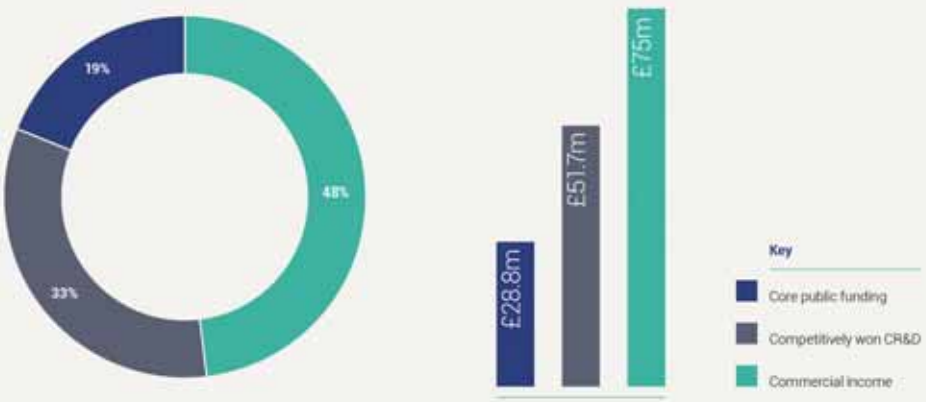
£474m

↑ Up 28% from 2013-14

Investment in large capital projects

£69.4m

Funding breakdown



Number of employees

1,577

Number of projects

1,259

Size of order book

£183m

→ Over 66% of which came from CR&D

Private sector clients

1,514

→ Over 41% of whom (629) were SMEs

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Biological research

Figures on the sector

Where we are now

Manufacturing the future

After years of bad press, manufacturing makes a comeback. The recession has reminded us of the importance of "making things", and the robust performance of UK manufacturing recently has impressed (and surprised) many.

These pages aim to reflect what is going on in this new world of manufacturing, from factories influenced by the "Internet of Things" – in which objects as well as computers are connected to the internet or to each other – to biological science.

Connected factories are going to make life easier for many manufacturers very quickly. In the old world if a machine part wore out, it took human intervention to spot it breaking down. In a connected environment the machine can send an alert to a central system and ensure that the fault is logged and remedied. It gets better as more systems become connected and linked to an overarching console at the front, including data from the shop floor and back-office business systems, allowing for a complete view of operations at all times.

Biotechnology is also offering advances. As the article on page eight observes, this is nothing new; when people found you could make wine by adding yeast to grapes, they were using biotechnology. Some thousands of years later, we have a different picture; the biological processes in manufacturing are known to have effects on the environment, through carbon emissions, climate change and more. Balancing the ecological books while remaining productive is a complex process.

Labour kicked off the High Value Manufacturing Catapult late in the past decade. The coalition government picked up the idea and Vince Cable explains his view in this supplement, as does the current chair of the All-Party Parliamentary Group on Manufacturing, Chris White MP.

It's an evolving area, and one that will continue to make the economy grow. ●

Guy Clapperton

This supplement and other policy reports can be downloaded from the *NS* website at newstatesman.com/page/supplements

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The paper in this magazine originates from timber that is sourced from sustainable forests, responsibly managed to strict environmental, social and economic standards. The manufacturing mills have both FSC and PEFC certification and also ISO9001 and ISO14001 accreditation.

Manufacturing matters

Developing the sector should not be left just to the market. With the long lead-in times for developing goods such as new drugs or energy infrastructure, Britain needs some kind of industrial strategy, writes **Vince Cable**

The crisis in the steel industry has reminded us that we still have manufacturing; that thousands of workers depend on it; and that the rebalancing of Britain's economy towards traded industrial activities is precarious at best.

For decades manufacturing has declined as a share of the economy – from 26 per cent in 1980 to roughly 10 per cent today – while employment in factories has declined even faster – from 6.6 million to under 2.5 million over that period. Yet, as a share of the economy, the UK manufacturing sector is similar in scale to that of France or the United States, though much less important than Germany's (about 20 per cent of GDP), Japan's or Italy's. Moreover, the output and employment figures don't fully capture the importance of the sector, for several reasons.

First, manufacturing contributes disproportionately to productivity growth and thus to the growth of earnings and the standard of living. Some of Britain's leading plants, such as the Nissan car factory near Sunderland, are among the most efficient in the world. The flipside of that achievement, however, is a dramatic fall in industrial employment as robots and sophisticated process systems make workers redundant.

Second, and related, manufacturing is the main user and generator of research and development, leading to innovation, productivity growth and the creation of intellectual property, in the form of patents and copyright. Britain lags behind the rest of the developed world in R&D, which is both a cause and an effect of a relatively small manufacturing sector.

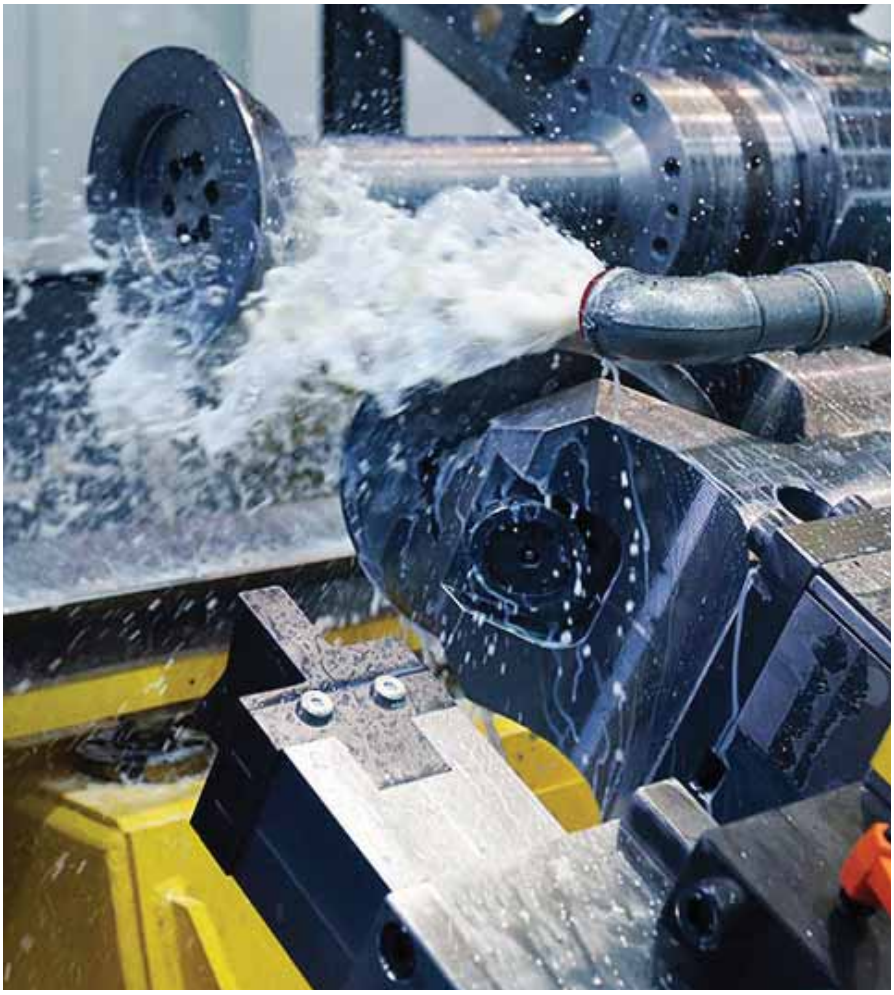
Third, manufacturing is a disproportionate contributor to exports (accounting for roughly half of visible exports). Britain's weak trade performance in recent years is largely accounted for by the deterioration in manufacturing; a trade surplus of 5 per cent of GDP in industrial goods in 1970 has become a deficit of over 5 per cent of GDP today. The fact that we have a floating exchange rate has removed the sense of crisis and urgency from that deterioration, which is in turn partly due to a prolonged period of over-valuation (the corollary of a strong currency). Nonetheless, the poor trade performance is a symptom of an underlying imbalance in the economy: a weak tradable sector, where manufacturing is central.

> Manufacturing is the main user and generator of R&D, leading to innovation

Manufacturing matters. But the popular notion of manufacturing – workers (mainly men) working on machines and making things – is increasingly at odds with reality. The borderline between services and manufacture is becoming very blurred. A large part of the value of advanced manufacturing products – a car, an aeroplane, a new drug – consists of such activities as design, drawing on the skills of creative arts as well as engineering, laboratory research, software and systems development and brand marketing. Some of this work may be done inside a manufacturing company or it may be outsourced to service providers. And much of the investment is in "intangibles" rather than plant and equipment in the usual sense.

It is this fuzziness, caused mainly by the advance of digital information technology, which leads some policymakers to argue for a passive, "hands-off" approach by government. They will argue that we have no idea what disruptive technology will bring, so let technology rip and let markets decide which firms to back.

Markets will and should decide (though of course some markets don't work well or are dominated by monopoly suppliers, such as the big internet platforms). And technology will evolve in unpredictable ways. But these are not arguments for government passivity. On the contrary. Many areas of business activity have long lead times, longer than financial markets will normally allow. It takes decades to plan a new generation of aircraft, or major new transport and energy infrastructure and associated supply chains or new propulsion systems for motor vehicles, or to develop new drugs. And even in sectors



Manufacturing industries are at the cutting edge of creating intellectual property

characterised by rapid change and disruptive technology it can take many years to develop the specialist skills required, as in the case of software engineers.

It is, therefore, commonplace in the major, mature economies to complement market-driven processes with some kind of industrial strategy: collaboration between business and government to take account of long-term planning and externalities. That is why I launched an industrial strategy for the UK working in partnership with business (and unions) and on a cross-party basis. I consciously built on the legacy of my predecessors Michael Heseltine and Peter Mandelson. And I drew on the experience of countries that have something to teach us: Germany, the US, France, Japan and South Korea, among others. By the end of the term of the coalition government, valuable collaboration had been built up in sectors such as aerospace and automobiles, where public/private R&D partnerships had been developed worth £2bn and £1bn respectively, but also in creative industries, professional services and construction.

It is far from clear that the Conservative government understands the importance of industrial strategy or is committed to anything other than token participation. The visceral loathing at the Treasury of any kind of intervention involving government spending was a dominant force in the absence of the countervailing influences available during the coalition. Nonetheless, some deep foundations have been dug which it will be difficult to destroy entirely. Several building blocks are particularly important.

One is support for innovation. Britain prides itself on its science with some (if exaggerated) justification. But Britain lags behind in business application. Generous tax incentives – R&D tax credits, the patent box – have been introduced and are helpful. More directly, I introduced the network of Catapults, loosely based on a German model of innovation support for the country's *Mittelstand* companies.

A High Value Manufacturing Catapult is based around seven centres and is making a major contribution in areas such as new materials, forming and precision engineering. Other Catapults are helping UK companies make advances in cell therapy, stratified medicine, new renewables, satellite applications, energy storage, new transport systems and digital technology. A critical issue in the November Spending Review will be whether Catapults are supported.

Another key area is skill training. There are chronic shortages of engineers of most kinds, technician-level skills and construction skills. These problems are not new and immigration has acted as an escape valve, though this is increasingly difficult to manage politically. Under the coalition, significant progress was made in developing the quantity and quality of apprenticeships and opening up new channels for training through higher apprenticeships, as with the new national colleges for coding, railways and nuclear power. Even with the proposed new apprenticeship levy, the proposed cuts in further and higher education will severely undermine the long-overdue expansion of skill training.

And, not least, there is the series of initiatives designed to address the problem of "short-termism": the mismatch between the long-term time horizons of many manufacturers and the short-term demands of investors and lenders. I commissioned Professor John Kay to suggest a way forward and progress has been made to phase our quarterly reporting, establishing the long-term duty of directors and building in long-term mandates for the Takeover Panel and the Competition and Markets Authority. But the main advance has been the establishment of the Business Bank to create innovative forms of finance for SMEs, the Green Investment Bank, the Regional Growth Fund and the privately financed Business Growth Fund. We are beginning to create the diversity and long-term financing infrastructure taken for granted in Germany and elsewhere.

It would be tragic if the government now abandoned this endeavour in the interests of short-term cuts in the Budget. ●

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Automatic advantage

Simon Keogh, general manager for factory automation and control products at Siemens UK and Ireland, says SMEs through to large corporates should take advantage of today's automation technology tools to reduce investment risk, drive operational efficiencies, enhance production flexibility and increase competitiveness

There has been much discussion about the future impact of "Industry 4.0", the term originating in Germany to describe the next great industrial revolution leap made possible by the utilisation of cyber-physical systems. Advocates highlight a utopian view that, for example, will see the creation of self-organising, intelligence-led, fully optimised, digital factories producing highly customised products. The computerisation of manufacturing based on higher levels of network interconnectivity and enhanced digital communication between machines and equipment will allow this to happen.

But, while many grapple with the potential of such a substantial manufacturing advancement, we are already witnessing the influence of digitalisation within the industrial environment, and the fundamental power of automation tools such as simulation and engineering software which are making real inroads within an industrial context. As a result, a number of companies are benefiting from reduced capital expenditure investment risk, improved operational efficiencies, enhanced production flexibility, shortened time to market and augmented competitiveness.

Reducing risk, investing more

With the UK industrial sector acknowledged to spend considerably less than its German counterpart on investment in automation technology, encouraging increased numbers of manufacturers to instigate a more proactive investment strategy is a continuing challenge.

Mindful of difficult economic conditions, a traditional preference to rely on legacy systems and uncertainty over the ultimate benefits of automation technology, means many companies have shied away from investing in the proven automation systems that can underpin future competitiveness.

Seeing the investment risk and not the investment benefit has meant the UK's industrial sector remains behind the likes of Germany when it comes to productivity success.

Turning around the anti-investment sentiment will take time and requires action and support from all stakeholders, including the government and the banking community, to ensure real momentum can be generated in this critical area.

Linked to investment sentiment and a wish to lessen the perception of risk are the tangible benefits to be gained through the adoption of key automated simulation and engineering tools. Siemens's Totally Integrated Automation (TIA) Portal is a prime example of a gateway to a digitalised world that co-ordinates the production process by integrating software and hardware.

Product life-cycle management tools will, in a virtual digitalised world, design, prototype and simulate products to optimise development timescales. While other automation tools can, for example, design and simulate an assembly line to support the optimisation of logistics processes and production throughput – without the need to invest significant sums upfront. This type of digital capability is scalable, affordable and available across the manufacturing spectrum to the smallest SME as well as to a large-scale production facility.

Connecting critical phases

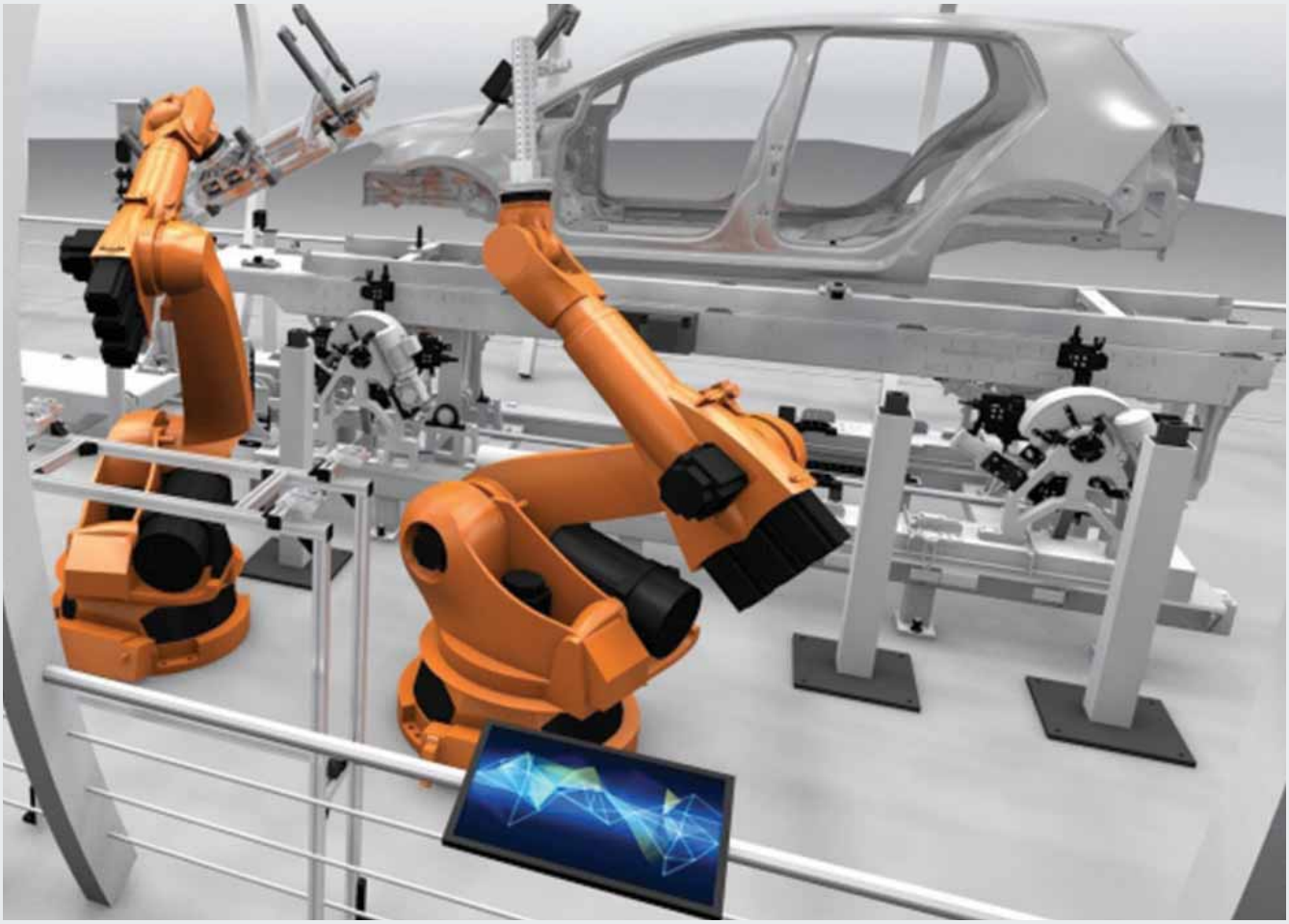
By taking a holistic view of the benefits automation technology can deliver, manufacturers can unlock the potential for operational improvement and increased competitiveness. Unified digital connections between the critical phases of product design, production planning, production engineering, and production execution, using relatively inexpensive solutions such as plant simulation, can shorten product development time frames, reduce costs and provide key insight to inform future investment decisions.

The preconception by management that there is an unquestioned need to invest in major plant infrastructure to upscale production capabilities can be quickly scrutinised and challenged within a simulated environment.

There are numerous examples of manufacturers avoiding significant capital expenditure after a simulation project has disclosed that better optimisation of the existing production execution will alleviate the requirement for additional plant, thereby saving the company substantial funds.

The near future

With the essence of Industry 4.0 based on the connectivity of the digital and physical worlds, the development of innovative tools such as "Automation Designer" will start



to have a real impact. Based upon a need for only one point of initial data entry, the system seamlessly integrates the process stages from mechanical design through to automation engineering, allowing changes to be made at any point that can then flow through the chain to save time and expensive resource commitments.

This manner of practical automation technology support starts to open up the optimisation possibilities that underpin the philosophy and vision behind Industry 4.0 for manufacturing organisations searching to take their product planning and production to the next level in order to remain competitive within their markets.

The advantageous essence of Industry 4.0 is already within reach for many who are prepared to shake off a historic reluctance to invest in integrated industrial automation technology. They should seek to embrace the competitive gains associated with the ability to shorten complex product development cycles and mass-produce customised products as efficiently and cost-effectively as possible.

About Siemens

Siemens is a global technology powerhouse that stands for engineering excellence, innovation, quality, reliability and internationality. The company is active in more than 200 countries, focusing on the areas of electrification, automation and digitalisation. One of the world's largest producers of energy-efficient, resource-saving technologies, Siemens is number one in offshore wind turbine construction, a leading supplier of combined cycle turbines for power generation, a leading provider of power transmission solutions and a pioneer in infrastructure solutions and automation and software solutions for industry. The company is also a leading supplier of medical imaging equipment – such as computed tomography and magnetic resonance imaging systems – and a leader in laboratory diagnostics as well as clinical IT. In fiscal 2013, which ended on 30 September 2013, revenue from continuing operations was €75.9bn and income from continuing operations €4.2bn. Siemens has roughly 362,000 employees worldwide on the basis of continuing operations.

Further information is available on the internet at **www.siemens.co.uk**

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Innovation through bioscience

In November, the Global Bioeconomy Summit opens. It is billed as "the first community-building platform to discuss bioeconomy policies globally". **Judith Batchelar**, chair, Agri-tech Leadership Council (ATLC), **Steve Bagshaw**, chair, Industrial Biotechnology Leadership Forum (IBLF), and **Lionel Clarke**, chair, Synthetic Biology Leadership Council (SBLC), take a look at what's in store

In January 2015, the German Bioeconomy Council produced a report detailing how each of the G7 member nations has started to embrace a wealth of biological resources to build their economies. Six member states have now published a national bioeconomy strategy: the UK, Germany, Canada, France, Japan and the United States.

Humanity is facing unprecedented changes on a global scale – climate change, population growth, changing resource availability and affordability, and health concerns all present mounting challenges that threaten future upheaval. Addressing and mitigating the consequences of these challenges will be of the first importance to humanity's long-term future and, as we continue our journey into the 21st century, the biological sciences are set to play an increasingly important role. Enter the bioeconomy, which is estimated to be worth €2trn within the EU alone and employs about 22 million EU citizens.

What lies behind these figures is the challenge presented by our continuing dependence on industries reliant on fossil fuels to drive our economy. What if manufacturing based on biology could integrate with existing technology to transform our process industries? Could this help the UK economy grow?

So what is the bioeconomy exactly, and is it anything new? Well, it can be considered as any economic activity arising from the generation of products made using biological processes and using biological solutions to address the challenges we face in food, chemicals, materials, energy production, health and environmental protection. Examples include using highly specific microbes to transform wastes into bioenergy or biofuels, or using plants as biopharmaceutical "factories" for reliable and rapid medicine production.

FIBERIGHT

Turning landfill waste into a resource

SME Fiberight is working with CPI and the High Value Manufacturing Catapult to demonstrate a commercial process for turning landfill waste into a repeatable sugar, a raw material in the production of biofuels, which replaces cereal crops for non-food applications.

Mixed household waste will be processed by applying industrial biotechnology into high-value chemicals and biofuels. This essentially turns a problem waste into sustainable products, replacing mineral oil as a feedstock. ●

http://fiberight.com

The importance of the bioeconomy lies not only in providing solutions to pressing social and environmental needs – such as reusing waste and providing alternatives to fossil fuels – but also in delivering real benefits for the UK (and elsewhere) through creating new companies, new products, new jobs, policy and advice, and contributing to the green economy through increasing UK exports and inward investment. Furthermore, it's not only about viable profit-making companies and tax revenues. It includes instances in which the application of bioscience brings about substantial economic savings by averting disease epidemics in human beings and farm animals.

A great example of this has been the eradication of bluetongue virus in UK farm animals and the prevention of its re-emergence in 2008, which is estimated to have saved the UK economy approximately £480m and saved up to 10,000 jobs in the agri-tech sector. Scientists at the UK's Pirbright Institute developed tools to predict the arrival, spread and re-emergence of the virus using their understanding of the behaviour and movements of midges within Europe. This enabled the assessment of the threat that bluetongue virus posed to the UK and a highly targeted vaccination of at-risk livestock.

As to whether the bioeconomy is "new", the answer is essentially no. For millennia, ever since we learned to harness yeast

Building a platform to commercialise

biology in fermentation to make alcohol, human communities can claim to have had a bioeconomy of sorts. What is new is the emerging breadth of the bioeconomy across the globe and the way in which it is expanding rapidly as advances in innovative biotechnology are being delivered. It will begin to pervade many more areas of our lives than it has done previously and we will likely see the "greening" of entire industries through new biological ways of making the same products.

Take the chemical company Croda, which already uses a sustainable bioprocess based on plant cell culture to manufacture a skin anti-ageing product. At the same time, we will likely see the emergence of bio-based products that we have not yet conceived. Bio-based products and processes already support a raft of critical industrial sectors in the UK, including agriculture and food, energy and chemicals, pharmaceuticals and healthcare, and consumer goods.

To adopt this new, broader bioeconomy, we need to react appropriately to the grand challenges society faces; how we react to these changes will make them either an opportunity or a threat. The UK is in a strong position to harness the chance to deliver sustainable solutions – the opportunity comes from supporting the bioeconomy, while the threat comes from not doing anything or implementing policies (for example, affecting regulation) which block relevant advances. We should also continue to nurture the world-class research, training and innovation that exists in the UK and enable UK scientists to work in partnership with the best international collaborators and policymakers across the globe. This increases the impact of their research and maximises the value of UK investment from both government and industry. The major UK funding bodies, say, have invested approximately £100m since 2012 in industrial biotechnology and bioenergy. This investment includes support for a number of technology and innovation centres such as the Centre for Process Innovation (CPI), which works in partnership with UK companies to prove and scale up research into new processes. CPI helps companies to take the risk out of the complex process of translation from laboratory to production plant and so increases the probability of commercialisation.

Similar investments have also been made in the areas of synthetic biology and agri-tech. All have successfully leveraged investment from industry to accelerate the transition in UK biotechnology through collaborative partnerships. This investment and support for the bioeconomy needs to be maintained in the long term, as it can take many years for new businesses to be created.

The UK has shaped a positive environment for those willing to invest in the bioeconomy and it needs to build on this good start. Continued investment through public-private collaboration is essential to maintain confidence and the momentum to develop the products, processes and services that can help transform industries and society.

Developing biotechnologies such as advanced sequencing, synthesis and analytical techniques will help to build a platform for UK-based companies to commercialise. In addition, work in these exciting innovative technologies can help inspire today's young people to study the sciences and engineering – they will provide tomorrow's bioeconomy workforce.

A thriving UK bioeconomy that integrates with our existing industries is likely to be a major part of the solution we need to address our dependence on imported fossil fuels and reduce the damage we do to our environment. It may even help bring back consistent economic growth.

It is clear that we will need to move away from our reliance on the earth's dwindling natural resources. Are we ready for a new bioindustrial revolution?

MIDATECH

Oral Insulin Delivery

Midatech is running a development programme with CPI and the High Value Manufacturing Catapult to scale up and commercialise the manufacture of insulin-coated gold nanoparticles that are being used in a new insulin delivery patch. The patch uses insulin attached to inorganic gold nanoparticles that are formulated into a dissolving film for the oral delivery of insulin to diabetic patients. This patch will eliminate the current invasive method of injecting insulin into the patient.

http://www.midatechpharma.com

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“A car rolls off our Ellesmere Port production line every minute”

Stefan Fesser, director of General Motors’ Ellesmere Port plant, explains the expanding role of manufacturing in the UK

The CBI believes that time lost due to congested roads is set to increase by 60 per cent by 2035. What effect do you believe this will have on General Motors UK’s manufacturing, and how do you plan to overcome this?
Congested roads not only have an effect on how quickly we can deliver our vehicles to the UK and European retailer network but also how quickly parts are supplied to the factory. This is why we are strong advocates of using local suppliers to Ellesmere Port, and as our roads fill up this will become even more critical to keeping the cars rolling off the production line. In addition to this, we at Ellesmere Port are following the progress of HS2 very closely. Not only will this link business between the north and the south but it will also free valuable space on our congested rails to make rail freight more competitive and flexible.

Why is it important that manufacturing remains in the UK?
Manufacturing represents a large proportion

of the UK's economy and the supply chains that sectors such as automotive rely on add further value to the economy. Manufacturing is no longer just about production, it is a much broader set of activities that add value and benefits for the wider society. Manufacturing includes significant innovation; it creates jobs that are both highly skilled and well paid.

We recently commissioned a study through CEBR which estimated that every one full-time person we employ at our plant is worth an additional three jobs to the wider regional economy. For every £1 we invest in our plant it is worth over £3 to the wider economy. These induced employment and investment effects demonstrate the importance of manufacturing for our regional communities and just how much value added we have over other industries.

How has securing production of the new Vauxhall/Opel Astra helped Ellesmere Port?

Securing production of the new Astra has meant the addition of new employees to the workforce, 300 of whom have already started and whom I have personally welcomed to our manufacturing family.

With Astra being one of Vauxhall/Opel's bestsellers, with over 20,000 units sold this year alone, it is so important we continue to develop our workforce to remain highly productive and motivated.

Ellesmere Ports' history and Britishness is very important to Vauxhall and something we can continue to celebrate now that we produce the next-generation Astra. It all started with the Viva back in 1964 and since then we have never looked back and are constantly planning for the future. We see ourselves as a big part of Britain and I believe that is why we are strong in the UK market. British cars, British built!

Other than congested roads, as mentioned above, what else affects the UK's manufacturing competitiveness?

We compete regularly with plants across Europe for product and the UK still has a long way to go to improve its competitiveness in manufacturing. Business rates are a key policy area which makes our manufacturing uncompetitive. Not only does this put us at a disadvantage compared to other car manufacturers who build abroad, but disadvantaged when competing internally to build the new generation of vehicle. With Vauxhall/Opel having nine other plants across Europe, it is imperative our plant costs are as low as possible. Here in the UK we pay 60 per cent of Vauxhall/Opel's overall European business rates for only 8 per cent of the footprint. The UK is the most expensive of all OECD countries for business rates. Simply put, it places us at a competitive disadvantage.

> "HS2 will free valuable space on our congested rails"

The European car market's registrations for the first five months of 2015 increased by 6.8 per cent compared to 2014. In addition to this, the automotive industry is improving the technology and connectivity of its cars. How has Ellesmere Port had to respond to keep up with demand and the need for new technology?

Technologies such as 3D printing have been around sectors like ours for a number of years, predominantly for design purposes. As this technology is tested further we are now seeing how we can use it in our manufacturing processes. More recently for our new Astra we have used 3D printing for our pilot production models, printing parts to see how they fit into the new manufacturing process.

Given that a car rolls off our production line every minute, it would be difficult to see how 3D printing could be used in full production, given the time it takes to print, but you never know; reducing cost and waste are all very appealing.

Ellesmere Port is now a landfill-free site. Does Vauxhall promote corporate social responsibility (CSR) and reducing our impacts on the environment to its employees?

Vauxhall is committed to protecting the environment for its present and future success and also as an expression of the company's corporate citizenship. We try to involve our employees, customers and suppliers in our efforts to control and reduce our environmental impacts. This commitment covers the way in which we manufacture and sell our vehicles and products and promote their responsible use. Through formal environmental management, we will continually seek the most efficient processes and technologies, which control and reduce waste, pollution and CO_2 emissions.

We give our employees one CSR day a year to go into the community to support local people. Activities range from gardening to painting and decorating.

As the government seeks to transform the north into the powerhouse it once was, what can Ellesmere Port do to help?

Vauxhall has always been active in seeking bright new talents and bringing them into the business at the first possible opportunity. This has happened in the form of apprenticeships, undergraduate and graduate schemes. The advantage this gives us is that in five years they will still be young: however, they have already had great exposure to the business and loads of experience. This helps us to make the youth of today the leaders of tomorrow. Aside from this we also have a skills academy. The objective of this is to enhance the skills set of our workforce so that they are skilled in many areas of the production line, therefore becoming more versatile individuals.

On top of this, we plan to open it up to our supply chain so their employees can also improve their skills and knowledge. That not only helps us but also improves their employability for the future.

Search: New Astra

Smart factories to boost productivity

The digital factory can be a solution to low productivity, and provides an opportunity to reindustrialise the UK in a radical and future-proof way. Business needs to understand Industry 4.0 better, and its effect on jobs and corporate liability, for the tech evolution to match new customer demands. **Will Stirling** reports

Some factories in Britain will soon be using parts with embedded sensors that talk to the machines and verification devices, confirming where they fit, or how much torque to apply to that specific bolt. These parts will navigate themselves through the factory: for example, selecting a 15mm washer or a blue cap to the correct packaging area for a specific customer. Workers will transmit production information through smart devices, as gigabytes of data fly around invisibly, optimising the factory parameters in a performance feedback loop.

This is a vision of the digital factory of the future, what has also become known as Industry 4.0, a fusion of cyber-physical systems (human beings and machines co-operating at work), the Internet of Things and the Internet of Services. First coined in Germany, the German government is pushing it forward as part of its High-Tech Strategy 2020 Action Plan. Selling more German industrial automation equipment is one purpose, but the long-term goal is industrial security.

Despite rising evidence of reshoring manufacturing from lower cost countries, high labour costs in the West still make the manufacturing of many goods vulnerable to relocation. Automating manufacturing will, it follows, cut costs and keep more production here. While Industry 4.0 has not happened yet, companies are adopting examples of cyber-physical systems in Britain.

The main drivers for this, more an evolution than revolution, are real: productivity, product customisation, supply-chain responsiveness and quality. Airbus has to build up to 50 wing sets a month; it cannot achieve this without combining automated systems with a human workforce. Siemens UK's central technology officer, Alan Norbury, says firms like his own are faced with both a productivity puzzle and a customisation conundrum.

"Our drives factory in Congleton is given productivity improvement targets of 5 per cent year on year, which we hit. But increasingly customers want variation in their drives, so now the challenge is high productivity and to offer increasing customisation. That's hard." Congleton is a step-change factory – it took 90 hours to produce one drive from order: today it takes 60 minutes. The big challenge is to deliver this year on year, customise more orders, and grow the business.

Mass customisation is being driven by consumer power and technology. We have the technology to customise our own pizza order, and even track its delivery in real time on an app – or personalised doll, or mobile-phone case – so we demand it. Manufacturing has to catch up with social technology.

Other large companies, equally challenged by productivity and customer requirement variation, are embracing aspects of the digital factory. Jaguar Land Rover and Rolls-Royce use a 3D CAD "cave" at the Manufacturing Technology Centre (MTC) in Ansty near Coventry, with a similar facility at the Advanced Manufacturing Research Centre in Rotherham. Both centres form part of the High Value Manufacturing Catapult, the public-private-funded organisation that aims to deliver step-change gains in manufacturing productivity, to keep production in the UK. The cave system allows engineers to simulate how components fit inside an assembly and how that assembly would come together in manufacture: virtual-reality 3D computer-aided design. This is before parts are made or assembly processes trialled, saving factory time.

But is this level of factory intelligence across industry really necessary, in the process sector and for small businesses? Certainly in food, says Simon Keogh, business manager for factory automation at Siemens. "There is a greater need for retailers to refresh packaging and offers to suit different trends, constantly, and they are getting into more agile manufacturing," he says.

Government switches on to digital

While "Industry 4.0 – the fourth industrial revolution" is really a marketing term, the meaning and the underpinning technologies for I4.0 are serious. Companies that fail to respond to the new demands for customised products risk losing out to more efficient competitors.

"One recent change is that the UK government is starting to understand what I4.0 is: that this is something they need to

Companies that fail to respond to emerging demands risk losing out to more nimble competitors

know for manufacturing in the UK," says Dr Lina Huertas, technology manager in manufacturing informatics at the MTC in Ansty. In the summer, the Department for Business, Innovation and Skills (DBIS) commissioned a study of I4.0 in the UK to create a framework for its priorities. Two UK reps from industry and the DBIS participated in a recent Brussels round table on "digitising manufacturing", Dr Huertas says. "This debated what the priorities are for different nations and to co-ordinate a Europe-based strategy for I4.0." Today there are many projects funded by the European Commission that research and educate business about Industry 4.0 – the MTC is involved in three funded by the EU's Horizon 2020 research funding platform. The MTC also runs events to demystify the meaning of I4.0 for business.

Challenges to quick adoption

Cyber security has shot to the top of the agenda for many big organisations – consider recent headlines about big data breaches at the adultery website Ashley Maddison, for instance.

As I4.0 proliferates the two biggest legal factors in, and barriers to, its development are security and liability. "In a manufacturing plant where all internal components have their own IP address for connected communications, that creates a series of potential entry points for unauthorised intrusion," says Kit Burden, technology partner at DLA Piper.

But Burden suggests that the biggest hurdle for the digital factory is liability. "When you enter the IoT world, there is a multitude of information from different sources coming together, all integrated by computers rather than human beings," he says. "If the end result of that is an accident or mistake, it becomes much more difficult to work out who was to blame." Burden maintains this is the main reason why there are not more driverless cars on the roads. Google Cars has clocked up millions of miles on roads with a negligible number of incidents – on paper it should be omnipresent, but it is not.

"A three-way collision involving three driverless cars, or two and a human-driven car, would be very difficult to decipher from a liability point of view." The same problem will likely restrict the pace of development of I4.0.

And yet, given the combination of big economic drivers – productivity, customisation, quality control and cost reduction – the digital factory is inevitable.

EMPLOYMENT

Will a robot take my job?

The concept of using more intelligent machines is "not just automation to get rid of people", says Lina Huertas. "Industry 4.0 is about producing more value, either by optimising the way people do their jobs, getting them to exploit their intellectual capital and to make different kinds of decisions as opposed to doing manual jobs that do not add value." This, she says, needs policy support from government, to understand and support future labour mobility, rather than seeing technology as a divisive force. It's about moving people from less skilled jobs, to add value and raise their quality of life.

"One of the biggest challenges with I4.0 is understanding how a job is going to change, what are the new skills required, and changing the education system to respond."

Here there is tangible progress. The MTC's new Advanced Manufacturing Training Centre, a stunning new building, will combine mechanical engineering training, CNC practical and theory, with modules on CAD/CAM software and mechatronics, the fusion of mechanical and electronic engineering.

In addition, the EPSRC Centre for Innovative Manufacturing in Intelligent Automation at Loughborough and Cranfield Universities is working with the MTC and partners including Airbus and Aero Engine Controls on devising the most optimised assembly methods that combine robot and human actions.

Technology business groups such as GAMBICA and Bara, the British Automation and Robot Association, maintain that the displacement of less skilled labour in factories by automation will be more than offset by new, more skilled jobs – design, logistics management – as the business grows. But evidence of this happening is, to date, scant.

Strategies for value

Innovate UK's head of high-value manufacturing, **Zoe Webster**, explains its focus on supporting and taking the risk out of business innovation

The UK is among the world's leading manufacturing economies, with manufacturing businesses employing 2.6 million people, contributing 9.5 per cent of gross value added (£150bn), 50 per cent of exports (£255bn) and 69 per cent of business-led R&D. Innovate UK supports and takes the risk out of business-led innovation, supporting the journey towards commercial exploitation, and ultimately a contribution towards UK economic growth. Good examples of this are in our support for early-stage companies such as Versarien (*see opposite*).

All change

The high-value manufacturing sector continues to change rapidly, underpinned by enabling technologies such as digital, which have driven a revolution in production flexibility unimaginable even ten years ago. More recently, this has become the ability to produce smaller batches cost-effectively and even to make individually customised items, allowing companies to maintain (and increase) their market share by meeting consumer demand for greater specialisation and personalisation of products.

That process of moving from the old model of high-volume production of a limited range of products to one of lower volumes of a near-infinite range of products is well under way, with Innovate UK encouraging UK companies to innovate in this area, using tools from other sectors, such as the digital economy.

The nature of manufacturing is subject to further change as supply chains move

Transitioning from volume-drive production

in response to the cost and supply of labour and raw materials (moving back to the UK, in many cases), and to satisfy the desire to manage the complexity of global production efforts. The UK is in a strong position to demonstrate the new ideas and agility needed to take advantage of these trends. But innovation is high-risk and the strategic innovation, involving multiple organisations, needed to access some of the biggest opportunities doesn't happen on its own.

It isn't manufacturing companies alone that will benefit from increased levels of innovation: important industries in the UK such as aerospace and pharmaceuticals – and resurgent areas such as the automotive sector – all need the backing of a vigorous, innovative manufacturing sector. There are many high-growth opportunities, at home and overseas, that our high-value manufacturing capability can exploit. Innovate UK supports businesses targeting lucrative global markets and in sectors where the UK has particular research and development strengths.

A strategic plan for growth

The key to generating UK economic growth from manufacturing innovation is analysing the medium- to long-term challenges and opportunities, and mapping those against the UK's current and emerging capabilities. We believe that there are three overarching areas for growth through manufacturing innovation in the UK.

First, digital or smart manufacturing to increase productivity. Second, enabling manufacturing readiness at scale so that smaller companies can prove their innovations to their customers (often the large companies with a direct route to market) more quickly. Third, seeding early-stage manufacturing concepts to untap avenues of future revenues.

Innovative manufacturing processes invariably need to be tested at industrial scale, with access to high-level, cross-sector expertise, the latest testing facilities and the finance to carry them through that final step to market. Innovate UK's establishment of, and continued investment in, the High Value Manufacturing Catapult continues to help the facility to build its capabilities in these targeted national competencies. This helps to minimise the risks for UK industry in taking

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the latest manufacturing technologies to market.

Innovate UK's support for the manufacturing sector has helped to develop our aerospace industries (the UK is the leading European manufacturer, and ranks second globally), in pharmaceuticals and also in the automotive sector, where some years of targeted support for innovative technologies – particularly those supporting the development of low-carbon vehicle technologies – have led to a manufacturing resurgence and the onshoring of automotive manufacturing by a number of global players, benefiting the UK economy.

We are also starting to make just as big an impact with the newer technologies emerging from the UK's strong science and R&D base. Fibre-reinforced composite materials, plastic electronics and industrial biotechnology – all areas of Innovate UK investment, are already helping

> The sector is underpinned by technologies such as digital

to drive innovation in manufacturing. Our recent establishment of an industrial biotechnology "Catalyst Fund", in partnership with the research sector, promises continued support for innovations in this area, helping UK companies to gain a critical headstart in the global race to exploit this lucrative new area of manufacturing.

The future

The digitisation of manufacturing will continue to present exciting opportunities for UK-based manufacturers. This will be reflected in our future activities and we are exploring ways of encouraging the sector to innovate in this area.

These may include greater use of robotics and autonomous systems, data analytics or commercial models that involve end-users of products at the design stage of the product life cycle and continuously capture end-user feedback to inform continued product improvement. We will also continue to encourage businesses to pull ideas in from other market sectors – such as the gaming industry – in order to spark the generation of more, potentially lucrative business ideas. ●

VERSARIEN

Pre-revenue to £5m in three years

From its origin as a garage start-up, Versarien has become one of the UK's fastest-growing companies, with the support of Innovate UK

A materials business supported by Innovate UK has moved from a garage start-up to become one of the UK's fastest-growing companies. Quickly securing Innovate UK funding after being founded at the end of 2010, Versarien has experienced rapid growth since, growing from two people working out of a garage to a £5m business working on four sites and with a listing on the London Stock Exchange.

Neil Ricketts, the firm's founder and chief executive, said: "If we had not got that first grant from Innovate UK, there is no way we would have been able to pursue that market or create jobs. It took the risk out for our shareholders and created a huge amount of validation. It said that we had something very good."

£6bn market for advanced materials

Versarien specialises in commercialising advanced materials technologies, including metal foams, graphene and extruded aluminium. It is targeting a £6bn global market and expects to continue to grow.

Neil added: "We are a company that takes great ideas and forms those into products.

"Following its launch on the London Alternative Investment Market (AIM) in June 2013, the business is well funded and has been able to acquire two businesses, Total Carbide Ltd and 2-D Tech Ltd.

"It now employs 105 people across four subsidiary companies – Versarien Technologies, DV Composite Tooling and the two acquisitions."

"Support from Innovate UK has driven our business"

Versarien has attracted Innovate UK funding for innovations including materials for dental prostheses, work on the next generation of solar cells, and cooling systems for electric vehicles.

Its leading product, Versarien Cu, is a micro-porous copper that can improve efficiency up to ten times when added to liquid cooling systems. It can be used in thermal management systems in a wide range of industries, including computing, automotive, telecommunications and power electronics. Versarien is now talking to some of the biggest companies in the world about how Versarien Cu can be used in their applications.

Neil added: "We see Innovate UK as a real partner. It isn't just there at one particular time, it's there all the way through the journey.

"It has really driven our business. I don't think we would be in the position we are in without the contacts, the connections and the help we have received from Innovate UK.

"Versarien is a fast-growing business. We see that continuing. We are starting to explore global markets. We have opportunities in Korea; we have opportunities in the US and in other countries in the Far East. This business will continue to employ people in the UK and will continue to develop technology with the support of agencies such as Innovate UK." ●

Size of the prize

Talking about manufacturing is all very well but how much can it add to the economy and how do its internal economics work? **Lee Hopley**, chief economist of the manufacturers' association EEF, offers some answers

Technology, resilience, solutions, creativity and international: these are some of the characteristics I associate with UK manufacturing. While these may not be the words that consumers would use to describe our industrial base, an overwhelming nine in ten members of the public believe that manufacturing is essential for the UK economy to grow.

Such strong support for manufacturing is more than a romantic attachment to our industrial heritage – manufacturing businesses are part of communities right across the country. Over 2.6 million men and women in the UK make things for a living, and many more jobs are dependent on the sector. In recent years the public profile of manufacturing has increased as we have taken more pride in our successful sectors and companies.

But the economics of manufacturing are much broader still. The UK economy is still going through a process of repair following the recession that began more than six years ago. Growth has returned, but our economic ambitions go beyond this – we need all sectors of economic life in Britain to be contributing to the expansion; we need the government and the private sector to be ramping up investment for the future; we need businesses to be continuously improving their productivity to sustain higher living standards and we need to raise our export game to pay our way in the world.

If that is not ambition enough, businesses and policymakers alike must have a laser-like focus on the future. Big environmental and societal challenges lie on the horizon. Being equipped to tackle and manage challenges such as climate change and shifting demographics is the only way our economy will be in a position to turn these challenges into opportunities.

Manufacturing is already playing a big part in helping to ensure that our economy can meet these growth ambitions. UK companies have been working to get their growth plans on track by investing, training and innovating. Investment in modern machinery, for example, which can accelerate the diffusion of technology, is three times higher in manufacturing than its output share of the economy.

> Innovation helps manufacturers remain relevant

Industry also has a strong track record of improving productivity, with growth over the past five years roughly four times faster than the rest of the economy and on a par with major developed-world competitors. Higher-skilled employment in manufacturing has undoubtedly contributed to this stronger productivity performance. Over the past decade, the share of hours worked by employees with a degree qualification has grown by almost three-fifths. And with this come better jobs and higher pay.

As the players in an outward-looking sector, manufacturers are more than twice as likely to be exporters as firms in other sectors and exposure to global competition provides a further spur to improve productivity.

Arguably, one of the defining attributes of manufacturing is its inventiveness. Companies' commitment to innovation and the development of new products, services and processes has been remarkably resilient in the face of economic challenges and uncertainty. These investments smooth the path into new export markets and also allow manufacturers to be agile in response to new opportunities.

I see first-hand the importance of industrial innovation. For manufacturers – in their own words – innovation "helps us remain technologically relevant in the face of new and emerging technologies and competition. It shows customers that we are working to improve their businesses for future market requirements. And it enables the development of improved products and services, which gives us access to more market opportunities."

Wearable technology will play an active role

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From technical textiles and personalised medicines to low-carbon vehicles and nuclear supply chains, we have the companies and the capabilities to compete and grow in global markets.

And many manufacturers have been making the complementary investments in technology, people and business processes that will drive our industry forward. However, these day-to-day priorities for manufacturers – and the big, high-value opportunities for UK plc – can get lost in the headlines when global operating conditions become more difficult. And lots of recent signals, from official statistics to our own research among manufacturers, confirm that industry is sailing into choppier waters.

The globalised nature of manufacturing can increase market opportunities and make companies' order books more resilient in the face of ups and downs in domestic demand conditions. But it has its downsides, too: fierce competitive pressures, the lack of a level playing field, swings in exchange rates and ever greater risk of contagion from events in far-flung places all have the potential to hit orders, confidence and investment.

Many of these factors are currently coalescing for some industry sectors. The collapse in the oil price last year has hit metals and machinery companies hard as investment and maintenance in offshore extraction has stalled.

A long period of stagnation in the eurozone has contributed to depressed export growth and now concerns are bubbling up about the openings for strong expansion in emerging markets over the next year or so.

At least in the short term, the dominant story around UK manufacturing is likely to be one of declining output and a softer jobs and investment picture. Growth may be down, but manufacturing is far from out of the game. There are always sectoral and geographical hot spots, but, more importantly, manufacturing is on the cusp of much more significant change.

We are seeing the advent of great changes in technology which could profoundly change the way manufacturing looks and operates in the future. Within the next decade we will see widespread adoption of technologies and strategies that will allow manufacturers to be more flexible, more customer-focused and able to create more added value.

Developments such as the Internet of Things and cyber-physical systems, such as sensors and wearable technology, will enable machines to have a greater active role in manufacturing production processes. Big data and powerful analytics will allow these systems to process huge data sets and translate that information into smart strategies. Innovation cycles will shorten, but the manufacturing value chain will be more complex.

These changes are coming and the UK must be in the race. Nine in ten manufacturers believe that the UK should be taking a leading role in this fourth industrial revolution and two-thirds say that UK manufacturing's ability to compete globally will depend on keeping up with advances in such technologies.

There is clearly everything to play for. But manufacturers don't and won't succeed by operating in isolation. The embrace of future opportunities will be extremely intensive of resources and UK manufacturers will only be able to exploit them fully through collaboration.

There are three steps on the journey that we can start to take today. Manufacturers need to build their strategies for this technological revolution, government must commit to a well-resourced future for the UK's innovation infrastructure and, collectively, we must get a handle on our long-standing skills problem.

Companies must be ambitious and policymakers cannot be complacent. If we get this right there is no question that the size of the prize is potentially huge for industry and the UK economy. ●

Sources

1. *YouGov Survey for EEF, February 2014*
2. *Research conducted by Research Now on behalf of EEF in February 2015 among 206 senior decision-makers in UK manufacturing firms*

The world-class facilities at the Manufacturing Technology Centre in Coventry, part of the national HVM Catapult

Remaining at the top of the game

The High Value Manufacturing Catapult fosters advanced practices in the UK and helps smaller businesses with access to advanced equipment they might otherwise not be able to afford, as the HVM chief executive, **Dick Elsy**, writes

The UK's economic outlook at the end of 2015 is not as robustly positive as it was 12 months ago. Global economic turmoil, challenges in China, plummeting crude oil prices and lingering uncertainty in the eurozone have not left the UK's economy and industry unaffected.

It is no surprise that the latest EEF outlook shows a dip in manufacturing output and export orders, as well as a dampening of manufacturers' confidence in their growth prospects. What is encouraging, however, is that those manufacturers also show a remarkably steady commitment to continued investment in innovation and technology.

This commitment is particularly important because at times of turmoil and difficult trading conditions, it is more critical than ever to outperform overseas competitors; by producing products better and more quickly, safely and cheaply in a more resource- and fuel-efficient way. That requires the development of new ways of manufacturing. Such innovation, however, is not without its risks.

Ambitious manufacturing companies which recognise that they need to innovate to grow face many challenges in bringing that innovation to market: there is uncertainty of outcome and they are confronted with making significant investments in new equipment and technology without any guarantee of success. At the extreme, a business could find itself at a "bet the ranch" crossroads where the need to invest in significant new technology is tempered by the consequences of failure if it does not deliver.

Help is on hand. By working with our centres in the High Value Manufacturing (HVM) Catapult, companies reduce that risk significantly because they will have access to the facilities, specialist equipment and expertise, while deferring the investment decision until it has been established that their innovation can be scaled up and is realisable on a commercial scale. Taking the risk out of this process from innovation to commercialisation is at the core of what we at the HVM Catapult set out to do.

The HVM Catapult was established by the UK government in 2011 to address the gap between groundbreaking innovation and invention (where the UK has a

world-class track record) and industrial-scale commercial applications (where the UK has too often let others reap the main benefits). The HVM Catapult formula is based on a business offer that covers the full range of manufacturing capabilities, providing access to advanced equipment that is normally out of reach for small and even big businesses. The Nuclear Advanced Manufacturing Research Centre (AMRC) in Rotherham, for example, has the largest machining centre available for collaborative research in the world, the Advanced Forming Research Centre in Strathclyde has recently acquired the largest superplastic forming press of any European research environment, and the Manufacturing Technology Centre in Coventry houses one of the world's most powerful commercial lasers.

This cutting-edge equipment is combined with extensive manufacturing process knowledge, the brainpower of experienced engineers and researchers from our university partners, and, importantly, R&D input from both small/medium-sized businesses and large companies. The crucial point is that partners share knowledge and work to a common goal, in an example of effective collaboration hitherto unseen in Britain.

I am a firm believer that if you bring together like-minded engineers and scientists with a common goal, in a light-touch environment (devoid of politics and heavy-handed management), they will naturally collaborate. This is the kind of collaborative environment we create at our seven centres.

The HVM Catapult centres often combine their specific capabilities into collaborative projects. The engineering group GKN Aerospace, for example, works with both the National Composite Centre in Bristol and the AMRC in Rotherham on the STeM programme, aimed at cutting assembly times for high-quality aircraft wing structures by 30 per cent.

Rich Oldfield, technical director of GKN Aerospace, says: "Having access to the resources of the HVM Catapult centres allows us to work alongside our partners to progress the technologies and processes that are critical to achieving our goals."

When Rolls-Royce worked with the team at the AMRC to achieve a substantial improvement in production capacity and productivity of the manufacturing of their fan discs, they developed a range of methods and techniques to deliver ambitious improvements. Among those techniques was the introduction of a titanium cutting system developed by a local SME, Technicut, and the Japanese-owned tool-holding specialists Nikken.

The introduction of this innovation contributed to Rolls-Royce opening a new high-technology disc factory in Washington, near Sunderland, as well Nikken opening a new R&D facility in Rotherham and Technicut exporting their tool to titanium machining workshops around the world.

What has been achieved to date

The HVM Catapult receives core funding from the government through Innovate UK, which must be matched with competitively won collaborative R&D and business income. This so-called one-third-one-third-one-third model is crucial to the success of the Catapult.

The government's contribution is critical to the success of the programme for a number of reasons. First, it shares in the risk of bringing challenging new technology to market. Without the government funding, industry would gravitate towards more vanilla-flavoured technology and we would lose our precious advantage derived from our world-class research. Second, the funding means that the HVM Catapult does not need to be a holder of the intellectual property that is developed. We have no commercial imperative to exploit it internally – the IP is for our industrial partners to use to add value. Third, it helps us work with smaller businesses, as well as commercialising the most radical innovations which inherently have most risk associated with them.

> It is more important than ever to outperform overseas competitors

It also sends an important message to business that the UK government fully backs high-end manufacturing.

I know that the UK government, and the UK taxpayer, get tremendous value from their investment in our work.

The full impact of innovation activities often takes many years to materialise. Yet our economic impact evaluation this year showed that we achieve £15 net economic benefits to the UK for every £1 of government core funding we receive.

It is the tangible benefits that convince businesses to work with us. And we respond to, as well as anticipate, their requirements. The doubling of the AFRC facilities, the Factory 2050 building in Rotherham, the recently opened National Biologics Manufacturing Centre in Darlington, the Aerospace Research Centre in Ansty, the National Composites Centre extension, the newly installed machining capability at the Nuclear AMRC and the Battery Scale-Up Centre at WMG are examples of the significant investment and expansion that happens across all our centres in response to industry demand.

And it's not just the big businesses (such as Rolls-Royce, Boeing, GKN and Jaguar Land Rover) that work with the HVM Catapult centres. Last year, over 40 per cent of our paying customers were SMEs. Companies such as PragmatIC, a university spin-out company that develops imprinted, ultra-thin microcircuits that are cost-effective enough to be incorporated into disposable items, ranging from intelligent packaging to wirelessly traceable documents.

Working with the HVM Catapult through the Centre for Process Innovation (CPI), the company was able to access dedicated engineering support, a controlled operating environment, access to collaboration partners and instant credibility with customers and investors.

Scott White, CEO of PragmatIC, summed up the benefit of working with the Catapult: ". . . the public access facility provided by CPI was perfect for us. We needed to scale up, and we were not in a position to do this on our own . . . The de-risking element, the access to world-class facilities without huge capital investment, is a crucial part of the journey from concept to commercialisation."

To date, we see that businesses of all sizes continue their strong commitment to innovation in advanced manufacturing in the UK and there is much evidence that the innovation infrastructure in the UK – of which the HVM Catapult is a core part – is working effectively.

It is critical that government continues to match this industry commitment on a long-term basis, to build a resilient, sustainable and balanced British economy that develops, makes and sells things around the world.

Workers for the factories of the future

Tailored clothing at off-the-peg prices may be the start of a complete change in processes and skills, writes **Bob Rae** of Sheffield University's Advanced Manufacturing Research Centre

The industrialised world is on the brink of a fourth manufacturing revolution. Water and steam powered the first industrial revolution, mass production fuelled the second and information technology was at the heart of the third.

The latest revolution – dubbed Industry 4.0 – marries the real world and the virtual world, and will be built around machinery with embedded electronics, software and sensors which can autonomously exchange data with other similarly equipped machines.

At one level, it opens the way to mass customisation, which already abounds in the automotive industry. Order a new car today and you choose everything from trim to power train, but your tailor-made car will be built on the same production line as other variants of the same model.

Clothing could be next, allowing individuals to order garments over the internet, made to their measurements, and sold at off-the-peg prices. However, that merely scratches the surface when it comes to the opportunities for creating individually tailored, mass-manufactured products.

Industry 4.0 encompasses technologies that the University of Sheffield's Advanced Manufacturing Research Centre (AMRC) will explore at its futuristic "Factory 2050" development, due to be completed in November.

Factory 2050 will be one of the most advanced factories in the world and is the first building on a new Advanced Manufacturing Campus, which could result in the university creating up to a million square feet of new research facilities on the site of the former Sheffield City Airport over the next seven to ten years.

The landmark circular, glass-walled structure, with its long rectangular extension, has been built with the support of a £10m grant from the Research Partnership Investment Fund, managed by the Higher Education Funding Council for England (HEFCE), and a further £10m from the European Regional Development Fund.

> Intelligent machines will monitor their own operations

Factory 2050 will be the UK's first, fully reconfigurable component manufacturing and assembly facility, combining new technologies including advanced robotics, flexible automation and virtual environments, linked to plug-and-play machine tools, robots and 3D printing technology, which can be moved around the shop floor to create new production-line configurations.

Professor Keith Ridgway CBE, the executive dean of the AMRC, is one of the authors of *The Factory of the Future*, commissioned under the UK government's Foresight future of manufacturing project. He says: "We want Factory 2050 to be the most advanced factory in the world.

"The development will ensure that the UK's advanced manufacturing supply chain can tap in to the expertise it needs to make the most of increasing requirements to make rapid changes to product design, as a result of ever-changing customer demands," Ridgway says.

"Factory 2050 has also been designed to make young people enthusiastic about following a career in advanced manufacturing. We want to see hundreds of kids' noses pressed up against Factory 2050's glass walls as they marvel at what is going on inside and want to be part of it."

Factory 2050 will help advanced manufacturers supplying the aerospace, automotive and general manufacturing sectors to respond to increasing demand for high levels of flexibility, automation and highly customisable products.

Roughly seventy staff will work with British industry to investigate and demonstrate the most advanced manufacturing

Factory 2050 aims to be the most advanced in the world

technologies, including robotics and automation and technologies that will enable manufacturers to switch rapidly between making high-value components and one-off parts, while responding to demand for rapid changes in design.

The possibilities include being able to design, develop and test prototypes in the virtual world, with a high degree of certainty that they will work first time when they are finally manufactured in the real world.

Factory 2050 will also give the AMRC the capability to develop "intelligent" machines and processes that can monitor and optimise their own operations.

Sophisticated monitoring systems will generate huge volumes of data, which will be used to develop technologies that allow machines to sense when something is about to go wrong and respond so that production is not affected.

Machines will also be able to change the way they work to maximise production and minimise costs while maintaining quality. The same data could also be fed to customers' and suppliers' manufacturing, stockholding and ordering systems to achieve further efficiencies.

Factory 2050 will be home to a number of new projects.

One will explore future digital factory technologies for one of the world's largest independent producers of commercial aeroplane structures, Spirit AeroSystems, while another, with the construction and engineering group Laing O'Rourke, will take aerospace manufacturing technology into the construction industry to help solve the UK's housing shortage.

Politicians want the number of new homes built each year to increase from the current level of between 140,000 and 200,000. In order to achieve that, while responding to consumer demand for affordable homes that are tailored to personal choice, the construction industry will need to make significant changes to the way it works.

The Laing O'Rourke group plans to do that by increasing off-site production, developing reconfigurable factories and automated assembly systems that can supply homes to construction sites as a set of modules.

The company believes the advances could allow a typical house to be built and be ready for occupation within a day, once site work is complete, and that zero-carbon-rated apartments could be constructed at the rate of one floor a day, with a typical block being ready for occupation in a week.

While the AMRC develops advanced ways of making modular systems for new homes, other buildings and supporting infrastructure, its award-winning training centre will identify training needs, develop accredited programmes and provide training for workers who are to use the new technologies and techniques the AMRC develops.

The training centre already provides advanced apprenticeship and higher-level skills training for about 300 young people employed by advanced manufacturers and has links with both Sheffield universities, enabling apprentices to go on to study for higher-level qualifications up to doctorate and MBA level, with financial backing from their employers.

It has won a Times Higher Education Outreach Award for bridging the manufacturing skills gap while also promoting social mobility, and has been named as one of the headquarters of a new National College for Advanced Manufacturing.

BOND BRYAN ARCHITECTS

A school for rolling stock

The Crossrail chairman, Terry Morgan, is pushing a major project that uses manufacturing and will help the UK's infrastructure. And he is driven to help the youngsters who will run the railways of the future, he tells **Guy Clapperton**

Cut Terry Morgan and he is likely to bleed manufacturing. Not only is he the chairman of Crossrail, he chairs the Manufacturing Technology Centre (part of the High Value Manufacturing Catapult), the National Training Academy for Rail and a private engineering company, Ricardo, which he also chairs.

Crossrail itself is the largest infrastructure project in Europe, and it is coming in on budget and on time. "What's important to me as chairman is the emphasis we put on legacy," he says. "That's about environment and sustainability; I have a particular interest in the importance of apprenticeships and vocational skills."

This is a theme that permeates the conversation. Among Morgan's roles at HS2 is to chair the skills academy. Adding skills to the workforce is what he is largely about.

Crossrail will serve that workforce, he believes. "It's a rail programme that will add 10 per cent more network capacity in London," he confirms. "But it's much more than that. You put a railway down and it creates regeneration."

The scheme was predicated on the idea that over its lifetime it would generate over £40bn of benefit, which the management now considers is a conservative estimate. "Over 50 per cent of the current planning applications for development in London cite Crossrail as a key factor in deciding to do it now."

It's also about a lot more than London, he confirms. "We spend a lot of time going around the country talking to small and medium-sized companies about how they can access work with Crossrail. It will help with their supply chain." In terms of supporting UK manufacturers and business in general, he confirms that 95 per cent of the expenditure so far has been on UK companies and 60 per cent has been outside London and the south-east. Sixty per cent, indeed, has been with small and medium-sized companies.

Infrastructure is vital for the economy overall, and Morgan points out that London is projected to grow by 20 per cent by 2020. His office is in Canary Wharf, an area where 120,000 people pass through every day. "By 2020, when Crossrail is complete, Canary Wharf will be able to accommodate 200,000 people a day," he says. "Right now the other train lines are the only way of accessing the place and they're full." The same effect will apply to the former Olympic site, which will be accessible only if the transport infrastructure that is put in place.

> "My apprenticeship was more than learning to turn a lathe on"

Morgan hopes London will set a precedent. "One of the features of the Northern Powerhouse and other devolved local governments is that it allows the authorities to decide how to invest," he comments. The ability to spend on infrastructure programmes locally will add to the pressure for more, he says. "You build a railway for east/west [which he is convinced will happen], you're bound to ask how about north/south."

The challenge will then be to make the growth in infrastructure sustainable, Morgan says, and the way to do this is to give the workforce skills.

This is why Crossrail has stipulated in its contracts that its supply chain must offer training, and he is keen to see HS2 do the same. "The national colleges with which I'm involved will recruit 1,000 apprentices by 2017," he says. The companies that perform best in the programme so far have not needed prompting: they just train. "It's criminal that many organisations do not invest in apprenticeship programmes. They rely on skilled immigration and poaching the best people. They then don't perform well because they don't invest in their people."

His great joy is that most of these projects are apolitical. His own background is as an apprentice, having started a six-year apprenticeship in the automotive industry 50 years ago. "I look back on my apprenticeship with a degree of fondness," he says. "It was [a time of] learning skills but there was a broader application; I was learning about myself and becoming a useful citizen. It was much more than learning how to turn a lathe."

Morgan sees that things have changed for the better in manufacturing, and he considers the Catapult programme an important step. It arose from the financial crisis and the need for a balanced economy, learning a lot from the German model, in which turning an idea into a commercial proposition is central. "It was a movement kicked off by Mandelson, went through the coalition and is now with the Conservatives – it's travelled well." ●

Manufacturing a resurgence

Making things is critical to maintaining a balanced economy, and recent developments, such as 15 per cent of UK manufacturers reshoring jobs and 670,000 young people holding an apprenticeship, show a sector that is making a contribution. How can policymakers help, asks **Chris White MP**

Anyone with a passing interest in manufacturing, will be familiar with the soundbite "the white heat of the scientific revolution" by Prime Minister Harold Wilson in the 1960s and more recently Chancellor of the Exchequer George Osborne's "march of the makers". These words were intended to highlight this country's potential to produce and to export, using the most innovative and effective technology at our disposal.

The All-Party Parliamentary Manufacturing Group (APMG), which I co-chair with Barry Sheerman, the Labour MP for Huddersfield, is drawn from parliamentarians of all major political parties who have a common interest in and passion for UK manufacturing. We are one of the most active all-party groups and also, I would argue, one of the most effective, not least because we are ably assisted by the think tank Policy Connect as the secretariat.

Engineering UK's 2015 report, launched at the beginning of this year, makes the key assertion that UK manufacturing is, and must continue to be, an essential element of a balanced economy. Reshoring has been a significant factor and this should be regarded as one of the success stories of the past five years. With a favourable regulatory environment, including a competitive tax regime, companies have chosen the UK as the best place to do business. Over the past two years, reshoring has added £600m to the UK economy and created about 10,000 jobs.

As the same report highlighted, 15 per cent of UK manufacturers have brought production back from overseas during the past year, or are in the process of doing so. As these statistics show, and if this trend continues, the economic potential for reshoring and its associated benefits is huge.

I want to highlight three areas that I believe are worthy of discussion, if manufacturing is to continue its resurgence.

Investment in innovation is fundamental to manufacturing growth. As part of the right policy and regulatory framework, well-targeted investment in research and development provides the impetus for expansion. Support for such organisations as Innovate UK and the High Value Manufacturing Catapult, alongside policies such as tax credits for R&D, provide an environment in which innovation has the opportunity to flourish.

> Business's return to Britain is one success story of the past five years

There are many potential fields for the development of innovative technology, and one of these is Through-Life Engineering Services (TES).

The aims of TES are to improve the availability, predictability and reliability of complex engineering products; to deliver the lowest possible whole-life-cycle cost and to develop technologies and processes to improve the design and manufacture of such systems.

To achieve these, TES focuses on the design of a product in the first instance, extending the life of high-value equipment and tackling obsolescence, as well as focusing on preventative approaches.

The Royal Academy of Engineering reports that Britain will need an additional 800,000 graduates in the science, technology, engineering and mathematics (Stem) sectors by 2020.

To address this skills shortage, I believe we need to begin as early as primary school, where the study of Stem subjects should be promoted and encouraged for boys and girls alike. I support the government's focus on apprenticeships. It is pleasing to see provisional figures for the first half of the 2014/15 academic year which show that almost 670,000 people are on an apprenticeship.

Engagement with employers is vital to ensure that young people get the right skills, and 1,000 businesses are involved in designing the new apprenticeship standards. The government also offers grants to employers to encourage them to take on apprentices.

In my role as an MP and as co-chair of the APMG, I am proud of the progress the manufacturing sector has made. As the Chancellor said earlier this year, the Midlands should be Britain's engine for growth; my constituency of Warwick and Leamington has a proud tradition of manufacturing and I have been delighted to see the growth of local businesses, as well as others across the region.

However, we must ensure that we address the issues which the sector has identified as inhibiting its growth, and I look forward to working with others to achieve this goal. ●

Chris White (Conservative) was first elected as the MP for Warwick and Leamington in 2010

Britain's manufacturing sector at a glance

Manufacturing in Britain has long been perceived to be in relative decline, but the sector is as large to the UK economy as France's and the US's are to their economies – and it makes a contribution above its size.

2.6m
People employed in UK manufacturing

11%
Addition to UK GVA by manufacturing

72%
Proportion of UK R&D funded by manufacturing

No2
The UK is the world's second-largest aerospace manufacturer

54%
Percentage of UK exports that comes from manufacturing

up 100%
The value of exports to non-EU countries doubled between 2003 and 2013

40%
Increase in UK manufacturing productivity in the past ten years

£20m
How much chemical and pharmaceutical industries add daily to the UK's balance of trade

10%
The boost engineering graduates can expect in their starting salaries over other graduates