

Assignment 02
Introduction to Industry 4.0

**Impact of Adopting Industry 4.0 Technologies by SMEs in
Wales**

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24/01/2023

Abstract:

In the rapidly developing global village, the need for more efficient, sustainable and smart industrial technologies is more than ever to address more-informed needs of the public. Advanced manufacturing through automated energy systems, robotics, big data and 5G interconnectivity all has made this into a reality. Since its inception, Industry 4.0 technologies have shifted the balance towards more agile, sustainable and smart manufacturing through interconnected digital machines. As good as it sounds, industry 4.0 bring its unique challenges limiting this from adoption by small and medium enterprises. This report discusses the current situation of SMEs in Wales region highlight the challenges, and possible solutions through selective case studies.

Introduction:

The industry 4.0 or I4.0 is regarded as the 4th industrial revolution encompassing digital technologies such as Internet of things (IoT), cyber-physical systems (CPS), additive manufacturing (AM), artificial intelligence (AI) and block-chain (Shashank, et al., 2022). Fig. 1 shows the four stages of the industrial revolution and the key technologies in each era. It is a concept in which digital sensors, smart products, and intelligent devices coordinate between them, engage with the ecosystem to perform operations with a very limited human intervention (Gilchrist, 2016). Despite there are financial and infrastructural barriers in incorporating the I4.0 in the current working infrastructure. Today, large industries, business appear to be making the transition to I4.0 at a faster rate than SMEs as it needs substantial planning, policy, and organizational support (Agostini & Nosella, 2020).

Large businesses and industry happen to approach to I4.0 at a faster pace than SMEs due to the fact that they keep resources in substantial planning, policy, and organizational support (Agostini & Nosella, 2020). Overall, SMEs contribute to ninety percent of businesses and half of jobs worldwide, with a share of forty percent of GDP in developing countries (The World Bank, 2020). However, the implementation of I4.0 is not convenient for many SMEs due to the lack of standardised procedures and limited resources (Dassisti, et al., 2019) to address organizational, environmental, economic, and innovation-related challenges. This report envisage these problems while focussing on the SMEs in Wales region in the UK.

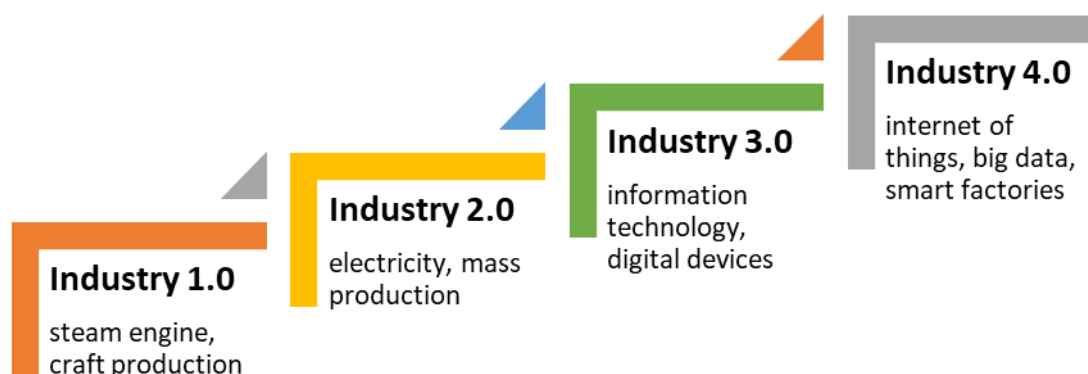


Fig.1. Evolution of industry 4.0. (Adapted from (Yin, et al., 2018))

The requirement for technologies in Wales?

Some of the smaller nations and developing countries have been undergoing transformation in adopting advanced technologies to meet challenges faced by rapidly changing market

needs e.g. productivity, innovation, value addition through sustainability (environmental impact) in their products and services. Wales is one such country in UK where development programs have been initiated by the local government by support of the EU development funds. Some of these such as (ASTUTE 2020, Sparc-II, CPE etc.) are to embrace emerging technologies in collaboration with the local manufacturing sector to develop new products and processes or improve the existing for market competitiveness and economic growth. This report will focus on the potential technologies and compare their impact on the Welsh economy, culture and other aspects. It is good to start by identifying the requirements for I4.0 technologies in Wales.

Geography of Wales:

The country may be famous for its beautiful valleys, extensive coastline, peaks and valleys, but Welsh manufacturing has had its own fair share of contributing to the economy. The mineral rich deposits and the development of the mining and metal working industries transformed Wales from an agricultural society into an industrial hotbed (Williamson, 2020). Fig. 2 shows the correlation between the human resource and the Welsh manufacturing sector indicating strong base for industrial manufacturing in metal products, transportation and food products. This indicates an existing industrial infrastructure exists already which may support embracing advanced technologies for increased productivity and business growth. However, comparing the current status of advanced manufacturing in the region, indicates the drive for transformation is quite slow. It is required to discuss the challenges, which are bottleneck to adoption of I4.0 technologies in Wales.

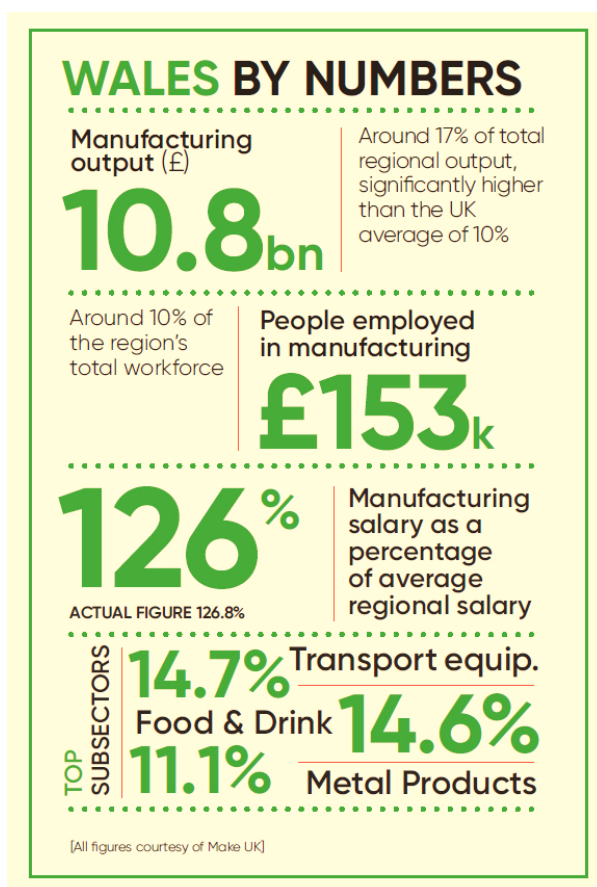


Fig 2. Welsh Manufacturing statistics sourced from web (Williamson, 2020)

The current status of I4.0 technologies across Wales and challenges in adopting the disruptive technologies will be discussed in line with the report by committee of experts from Welsh Government who sought to raise awareness of some key ideas about how Wales is preparing for I4.0 (Committee, Economy Infrastructure and Skills, Aug 2018). The key challenges anticipated are; adoption of I4.0 technologies require wide scale automation, faster networks and data communication for industrial internet of things, developing human resource to train in advanced technologies such as robotics and automation, data communication, creation of 5G test beds and rapid response supply chain, track and trace systems, block chain technology, to retrain and upskill workers who will be at risk of displacement by automation in the early stage of technology transfer. Another challenge arises from cyber security and ethical use of data, will require robust control and transparency to safeguard how data is stored, processed and communicated. The automation of technologies and integrated manufacturing systems means more office and desk-based work leading to grossly inactive lifestyles and mass obesity issues exacerbating pressure on health care services in the UK.

The challenges indicate where I4.0 will be leading Wales in the next 20-30 years, its is required to assess why these technologies are needed to be adopted in the first instance. Keeping in view the fast-paced developments in the science and technology, climate change, 5G digital networks, fast logistics, drone technology and changing human lifestyle are leading factors towards the need for interconnectivity of physical systems or creation of cyber physical systems, digital twins as we speak about the I4.0. The COVID-19 pandemic which brought in demographic changes and social distancing protocols impacting how we live, work, travel and spend. We observed surge in business activity shifting from on street shops to online e-commerce chain, e.g. Amazon indicated sales jumped to 44 percent higher compared to previous year (Weise, 2021). Likewise many other instances of online shopping, funds transfer, banking, health and other sectors may be quoted having blown off by the transformation during the COVID outbreak, inducing an uncertainty of things, shortage of commodities, a war like scenario. Need for industrial transformation is therefore anticipated to cope with the rapidly changing dynamics of our society.

In addition, developments in digital technologies, process automation, surveillance and inline monitoring have spurred strategic decision making to boost cost-effective, sustainable and transparent operational needs. The concept of lean manufacturing and six sigma protocols, artificial intelligence (AI) all indicate a gradual transformation towards automation, advanced controls with less human intervention and manual errors. Wales appears to be in the winds of the industry 4.0 technologies, which they may embrace in the future, it is always on the cards to lace up and prepare for this change and follow where tomorrow leads. Wales economy rests with industrial base in compounds semiconductors, food and drink, healthcare and insurance, transport equipment and metal products. The government must identify the competitive advantage where future growth areas are located, support those sectors to be at forefront of global market. The potential businesses, SMEs needs to be informed and made aware for Welsh govt support before seeking UK funding opportunities to reap maximum benefits for the Welsh economy and job creation.

Hereafter a few case studies are included to highlight the current state of the art and how challenges to the I4.0 adoption by SMEs are being addressed in Wales region. First, let us consider some advantages anticipated by adoption of I4.0 technologies by SMEs.

- 1) More control of product quality and maintaining the standard
- 2) End user, customer satisfaction on product quality
- 3) Allow early identification of system faults, diagnostics and timely troubleshooting at source when required
- 4) Green manufacturing will make industrial process cleaner and more cost-effective
- 5) It will contribute to sustainability, reduce environmental impact and waste generation
- 6) More efficient resource utilization

Case-Study-1

In order to join the future industry needs AMRC Cymru has been established in Wales. The state-of-the-art centre is fully funded with £20m from the Welsh Government and is managed by the University of Sheffield, focuses on advanced manufacturing sectors including aerospace, automotive, nuclear and food in the key research areas of future propulsion, sustainability and digital manufacturing. It is predicted the new facility could add to the Welsh economy by as much as £4 billion over the next 20 years (AMRC Cymru, 2021). Several successful case studies have been accomplished by the project teams in collaboration with the key industries in Wales, for example, food and packaging. The challenge was to speed up adoption of innovative eco-friendly packaging and waste reduction by integrating Industry 4.0 technologies. The work made use of variety of digital technologies including prototyping, material testing, vision systems and advanced automation in a systematic approach to develop a cost-effective solution for sustainable food packaging. Additional examples and case studies can be identified from AMRC Cymru portfolio can be freely accessed online (AMRC Cymru, 2021). This shows clear motivation and preparation by the Welsh Govt to support the local manufacturers helping them to educate, train and support getting on the road to address challenges of the next industrial revolution. However, this is only one side of the coin and it is premature to infer at this stage how this pilot plant will impact the Welsh economy and the human society in the future. Would this industrial model create more jobs in digital technologies, or it will cost the people losing their existing jobs?

Other questions, such as sustainability, are closely related to the I4.0 and need to be addressed before implementation of advanced technologies. SMEs are conscious of the influence of their brand recognition and relation with various stake holders owing to growing public demand and pressure on sustainable products and services in recent times (Siegel, et al., 2019). Rather than random facilities and resources, the I4.0 technologies rely on interconnected machines and interfaces such as blockchain to control various operation from start to finish of product or process. This significantly reduce risk in redundant operations where workers are unaware of variations in the supply chain, raw materials, or machining operation due to manual errors. The blockchain technology provides a safe and secure product handling, which is tracked from source to the manufacturer and to the customer for traceability in case of loss or damage.

Case-Study-2

In order to explain the challenges, I would like to iterate an example case study from an SME, called "Gxxx Ltd" (for confidentiality), our team had opportunity to collaborate in the past. The enterprise specializes in developing advanced materials and technologies for the renewable energy market in the marine sector. They also work on range of graphene infused products for the marine environment. Since introduction of the ten-point agenda by UK

government (GOV.UK, 2020), they have been looking for R&D support to design a new product based on photonic solar panels for decarbonizing the marine and offshore industry. Maritime transportation is regarded as one of the major contributors to global CO₂ emission, Gxxx Ltd realized this and needed a robust technology to develop long-life solar module sealing to cope with the harsh marine atmosphere. Some of the challenges faced by their teams are summarised as follows:

- 1) Low-cost engineering solution
- 2) Long life sealing quality of solar module structure
- 3) Fast and reliable technology with minimum waste
- 4) Readily available supply chain, engineering support
- 5) Easy to be trained in and transfer to others
- 6) Low carbon footprint
- 7) Easy to integrate with industrial production line

The existing supply chain make extensive use of conventional technologies such as using plastics-based mounts and adhesives to encapsulate and seal solar devices, not just time consuming but the sealing quality was not perfect and long lasting due to degradation in the open marine environment. An advanced technology or manufacturing process was sought by the enterprise. Collaborating with the academic teams from Bangor University, a laser-based manufacturing process was developed replacing the plastics with stronger and reliable materials for welding and sealing. Advanced manufacturing through high energy laser welding technology is unique in the sense it is simple, faster, allows automation and generates minimal or no waste thus addresses major challenges for adoption of I4.0 technologies and integration to the existing industrial infrastructure. The adoption of the laser technology will contribute to the ten-point plan for green economy including £12 billion of UK government investment supporting up to 250,000 green jobs (Policy, 2021).

If we analyse the above case, it may be evident that drive for industrial transformation exists in Wales especially since the COVID pandemic in 2020 and green energy transition white paper introduced by UK Govt targeting net zero carbon footprint by 2050. The OEM of solar cells rely on existing supply chain for raw materials, mechanical components and electronic devices. Transition to the I4.0 technologies will connect these supply chains through a centralised network which will feedback to the manufacturer, Gxxx in this case, of the status of solar cell structural materials, specifications and key laser parameters that they need to finish manufacture of a bespoke solar energy system. The system will identify where a part with required specifications is not available in real time to make timely decision for alternate suppliers reducing lead times which will contribute to energy saving and sustainable development (pollution reduction) by the manufacturing sector.

Lasers make a key part of the industry 4.0 technologies, e.g. additive manufacturing to enable automation, remote operation, integration with robotics arms to replace parts, integration with inline monitoring through sensors and actuators, self-calibration. level checks and remote maintenance. However, like every other technology lasers come with their own limitations such as the cost, reproducibility, safety issues and trainings needs for equipment operation and maintenance, which are critical questions that challenge SMEs adopting the I4.0 technologies. Although there are alternatives to this such as new chip or semiconductors lasers are being manufactured and deployed as more powerful, stable and

deliver defect free welding of dissimilar materials. With increase in the production of optical laser systems in China and global market competition the price is expected to decline gradually crossing the break-even point for potential investment by SMEs.

Apart from the financial support, one of the major challenges to adoption of I4.0 technologies by SMEs emerge from lack of knowledge, training and development of human resource (Agostini & Nosella, 2020) for which the top management has to play a key role and decision-making to ensure utilization of manpower before and after the transition phase (Nwaiwu, et al., 2020). It is also important to perform a comparative analysis, such as SWOT, to identify strengths and weaknesses of adoption of I4.0 technologies as proposed by (Saad, et al., 2021). Other questions, such as sustainability, are closely related to the I4.0 and need to be addressed before implementation of advanced technologies. SMEs are conscious of the influence of their brand recognition and relation with various stake holders owing to growing public demand and pressure on sustainable products and services in recent times (Siegel, et al., 2019). Rather than random facilities and resources, the I4.0 technologies rely on interconnected machines and interfaces such as blockchain to control various operation from start to finish of product or process. This significantly reduce risk in redundant operations where workers are unaware of variations in the supply chain, raw materials, or machining operation due to manual errors. The blockchain technology provides a safe and secure product handling, which is tracked from source to the manufacturer and to the customer for traceability in case of loss or damage.

Conclusions:

- The report highlights the Welsh industry scope for adoption of I4.0 technologies
- Typical challenges to SMEs are discussed and potential solutions/ideas are included
- Case study highlights the current state of I4.0 practice and training for public know how and business awareness
- Advantages and limitations are elaborated for SMEs
- Major barriers exist in lack of resources, short-term goals, resistance to change by employees, lack of know-how of digital technology, the need for hardware and software upgrading.

Recommendations:

- A well-defined business model for adoption of I4.0 technologies by SMEs is needed.
- All stake-holder including Govt, public and enterprise have to work interactively for effective strategy and implementation of I4.0
- International protocols and standards have to be defined for clarity
- Training, education and mentoring sessions should be organised for SMEs and new businesses

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Word Count 3058