

University of Wales Trinity Saint David

Introduction to Industry 4.0 (ACPA7004)

Assignment B – An Investigation into the Impact of Adopting Industry 4.0 Technologies by SMEs in Wales

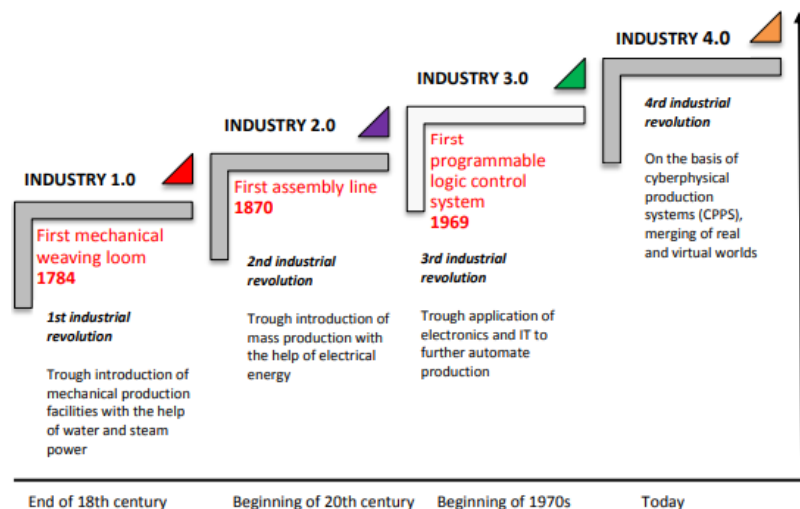
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The way businesses produce their products has been undergoing a significant transition for many years. The digitalisation of manufacturing has developed the idea of industry 4.0, which represents the fourth revolution which has occurred within manufacturing. The first industrial revolution represented the mechanisation through water and steam power, with the second introducing mass production lines through the use of electricity. The fourth revolution is an enhancement of what started in the third, the adoption of computers and automation, which now utilises smart and autonomous systems fuelled by data and machine learning (Marr, 2018). Each industrial revolution has been significant in the development of industries all over the world and without it, the world that we know today would not exist. It is important to understand what technologies are being employed by SMEs within Wales, the requirement for smart technologies and whether they assist SMEs in their response to business disruptions such as the covid-19 pandemic.



Ślusarczyk, 2018

As industry 4.0 is unfolding, more and more computers are connected and communicating with one another and managing to make decisions without human involvement. As described by Marr (2018), 'a combination of cyber-physical systems, the internet of things and the internet of systems make industry 4.0 possible and the smart factory a reality'. Therefore, the network of these machines that are digitally connected with one another and create and share information that results in the true potential of Industry 4.0. The use of smart machines in manufacturing will allow factories to become more efficient, productive and less wasteful. Prior to the pandemic, many businesses were struggling to find the talent or knowledge to introduce industry 4.0 technologies to their processes. However, several others implemented changes and prepared for a business where smart machines would improve their business (Marr, 2018).

One example of an industry 4.0 capability is identifying new opportunities. Machines have the capability of collecting tremendous volumes of data which can inform businesses of maintenance and performance as well as many other issues. They are then able to analyse the data and identify patterns and insights in a fraction of the time that a human would be able to (Marr, 2018). Ultimately, this technology allows businesses to optimise their operations quickly and efficiently by highlighting target areas in a timely manner.

A further example is optimising logistics and supply chains. A computerised supply chain connected to a smart system can recalculate and highlight priorities as new information becomes available. For example, if a weather delay ties up a shipment, a connected system can proactively adjust to that reality and modify manufacturing priorities (Marr, 2018).

Autonomous equipment and vehicles are further examples of an industry 4.0 technologies. The use of automatic cranes and trucks have become increasingly popular in shipping yards in order to streamline operations when accepting shipping containers from the ships. A similar technology would be the use of robots. Although this technology has been known to be more suited to larger organisations due to its high price tag, more affordable technologies have been introduced making it more suited to SMEs. Robots are commonly used for picking and packing in warehouses following their introduction by Kiva Systems which was later acquired by Amazon. Autonomous robots can quickly and safely support manufacturers, improving health and safety, increasing capacity and reducing lead times (Lynn, 2017).

The use of additive manufacturing, also known as 3D printing is also a popular technology being adopted by businesses. The last 10 years has seen tremendous improvements in this technology, allowing it to progress from prototyping to being utilised in actual production facilities, opening up more possibilities for production.

Lastly, the internet of things and the cloud are key components of industry 4.0. The utilisation of a cloud environment where data is stored, improves internal operations. SMEs are more likely to benefit from this technology as equipment and operations can be optimized by leveraging the insights of others using the same equipment (Marr, 2018). Although industry 4.0 is still evolving, its technologies are being adopted by businesses all over the world and companies who are adapting to its capabilities are realising its potential.

Manufacturing is more important to Wales than to any other part of the UK (GOV.Wales, 2021). With a long history of manufacturing in Wales, it is the largest contributor in terms of gross value added to the Welsh economy, providing high quality employment to thousands of individuals in Wales. The business population of Wales, similar to the rest of the UK is dominated by SMEs, accounting for 99% of the business population in Wales (GOV.Wales, 2021). The below table provides an overview of the business structures in Wales.

	Enterprise count	Employment	Turnover (£m)
Zero employees	204,350	224,700	3,431
Micro (1 to 9)	49,285	187,700	12,526
Small (10 to 49)	9,485	179,500	13,624
Medium (50 to 249)	2,215	146,300	16,795
Large (250+)	1,705	444,600	76,125
SME employers	60,985	513,500	42,945

GOV.Wales, 2021

In Wales, there are 12,110 tourism enterprises, accounting for 11.3% of registered enterprises in Wales in 2021 (GOV.UK, 2022). Many tourism businesses in Wales are food and beverage manufacturing facilities that expanded their business into visitor centres, linking the manufacturing

and tourism industries. For example, 6% of tourism businesses in Wales fall into the food and beverage service activities sector (GOV.Wales, 2022). Namely, Penderyn Distillery, Wales's largest single malt whisky manufacturer, attracts more than 40,000 visitors to their manufacturing facility each year.

The embrace of technology by small and medium-sized businesses (SMEs) across the UK has rapidly accelerated since the COVID-19 pandemic (The Open University, 2021), with the Welsh tourism sector being no exception. The tourism sector contributed heavily to the spread of the COVID-19 virus, later resulting in the introduction of travel restrictions and suspended activities within the tourism sector as part of the national lockdown.

Although all sectors were affected by the virus, most were able to adapt with minimum disruption in order to operate under new restrictions. For example, the non-food retail industry moved to online sales, some clothing and machinery/equipment companies developed other activities such as producing masks or respirators (Dalgic et al, 2021). However, of all the industries, tourism was hit the hardest during the pandemic due to the introduction of local and national lockdowns. With tourism being a significant sector of the Welsh economy, the immediate shutdown of 97% of tourism-based businesses and the furloughing of 80% of their staff, had a substantial impact on the economy of Wales. It is estimated that the North Wales tourism sector lost a total of £100 million in revenue throughout the 2022 Easter bank holiday period alone (GOV.Wales, 2022). Without the adoption of industry 4.0 technologies, the total loss for the tourism sector during this period had the potential to be much higher.

Research carried out by Be the Business confirmed that three years' worth of innovation took place in just three months due to the pandemic (The Open University, 2021). The onset of the pandemic forced business leaders to rapidly reassess how they do business and the role of technology and its potential impact on their operations. Technology is a key driver for productivity, especially for SME's and micro-businesses, which account for 99.7% of the total business population in the UK (The Open University, 2021). SMEs were obligated to explore and develop new technological skills in order to adapt to new ways of working for the purpose of maintaining the economy in Wales. This is exactly what the tourism sector in Wales had to do during uncertain times, as a bid to survive the pandemic.

When considering the increase of businesses relying on the introduction of innovations such as industry 4.0 technologies during the pandemic, it is evident that the adoption of technologies by businesses results in a more efficient, productive and resilient organisation. An appropriate example of this to consider is the work carried out by Cadw during the pandemic. Cadw is the Welsh Government Historic Environment Service who are responsible for promoting and protecting the historic environments in Wales. In March 2020, Cadw took the unprecedented step of closing all of their monuments to visitors and temporarily halting all on-site conservation work due to the introduction of local restrictions. In September 2020, Cadw offered a virtual 'Open Doors' event for four of their monuments. The Open Doors web pages received 8,829 page views and their success was such that they have become a permanent website feature (GOV.Wales, 2021). The introduction of virtual visits powered by advanced, interactive technology has promoted Welsh history during the pandemic and kept open the doors of many tourism attractions. Many privately owned tourism attractions followed in the steps of Cadw by adopting industry 4.0 technologies to maintain public interest during the pandemic. Penderyn Distillery also produced a virtual tour of their facilities in order to use as a marketing tool during the pandemic, it was utilised as a tool to show new export customers around the facility during travel restrictions.

Research conducted by Agrawal et al (2021) revealed that 51% of businesses would prioritise digital technologies for remote working, cloud-based collaboration and video conferencing when investing in industry 4.0 technologies. As well as making investments into these technologies, the Welsh Government invested into Cardiff based virtual reality experts 4Pi Productions as part of the Cultural Recovery Fund designed to support and sustain the cultural heritage sector due to the ongoing challenges resulting from the Covid-19 pandemic. 4Pi Productions were heavily involved in introducing industry 4.0 technologies such as 360° photography and 3D scanning technologies to businesses in Wales during the pandemic. These technologies were adopted by organisations such as Cadw who introduced virtual tours of their facilities as well as many other tourism attractions. It was also utilised by estate agents in Wales when in person appointments were restricted.

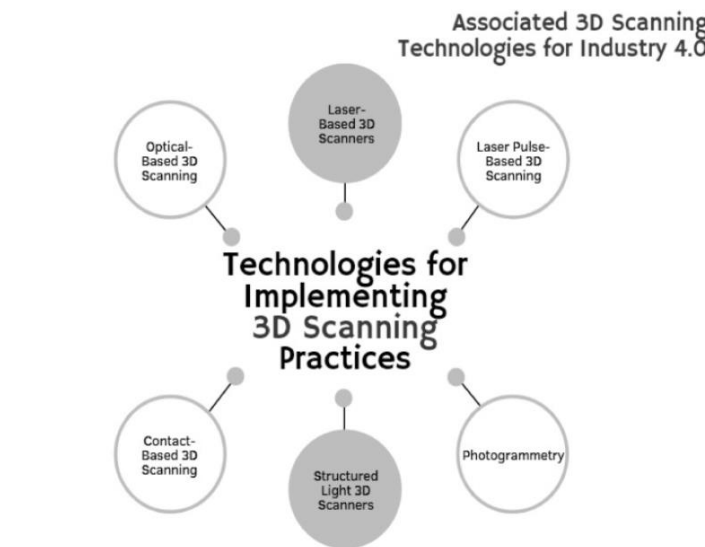
3D scanning technology evolves very quickly and allows designers to collect object data such as information about its shape, structure, and eventually colour (Dedic, 2019). Scanners can be divided into laser scanners and light scanners, which work on the principle of photogrammetry. This technology is often used in the construction industry and is mainly used for reconstruction of listed buildings or buildings of historic interest, this usually involves use of the laser scanners (Dedic, 2019). Light scanners would be used for smaller objects such as sculptures, or for scanning room surfaces, meaning that both types of scanners would have been used in the developments carried out by Cadw. Data captured in this way is very accurate and detailed, so much that it can be used for the creation of replicas. Professional software can be applied to transfer objects such as monuments into visualisations. The Artec Eva Lite 3D is an example of a handheld scanner used in the research conducted by Dedic (2019). This handheld scanner is commonly used to create high-quality and accurate scans, it is particularly suited for objects that have a rough surface. The principle of trigonometric triangulation is applied to the use of this scanner, which means the scanner projects a light pattern consisting of regular shapes on a scanned object. The scanner is then oriented along the edges of the shapes to produce the shape of the object. Suitable objects for scanning by this scanner are, for example, the human body, so this type of scanner finds use in scanning sculptures, archeological or artwork (Dedic, 2019). When scanning statues or monuments with stone blocks supporting them, this technology is used for the statue itself and the stone blocks are later modelled on a computer software such as Archicad 21. This software also allows individual scans to be further processed. The combination of the hardware with the optimum software and the user's knowledge generates the maximum benefit.



Lklevenow, 2018

Once the 3D scanning step is complete, the panoramic photography can take place in order to generate a virtual tour. A series of 360° panoramic photos is then taken at each scan station. With additional photographs being taken, consisting of 16 images, (one pointing towards the sky/ceiling, three towards the ground and 12 for the 360° circle in the horizontal position (Walmsley, 2020)). Software such as the PTGui automatically generates a spherical panorama which can be accessed as virtual tours via web browsers. This technology was employed by 4Pi Productions in the

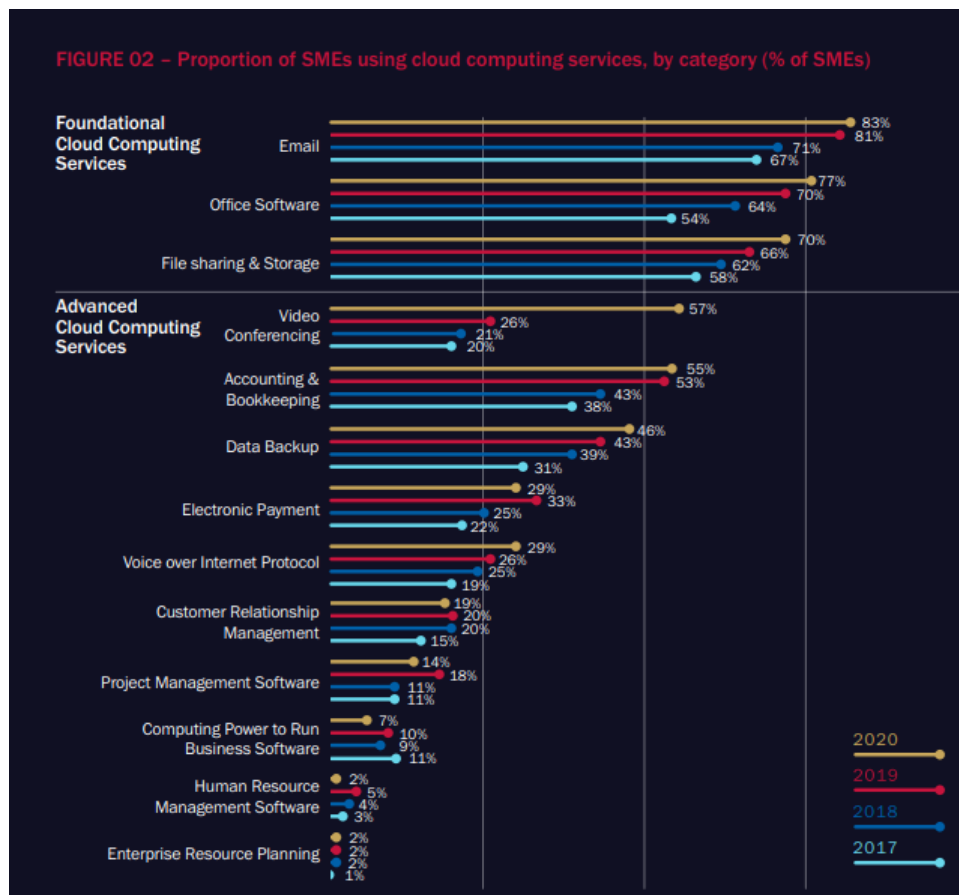
manufacturing of virtual tours for the Welsh tourism sector, although different software and equipment may have been used.



Haleem et al, 2022

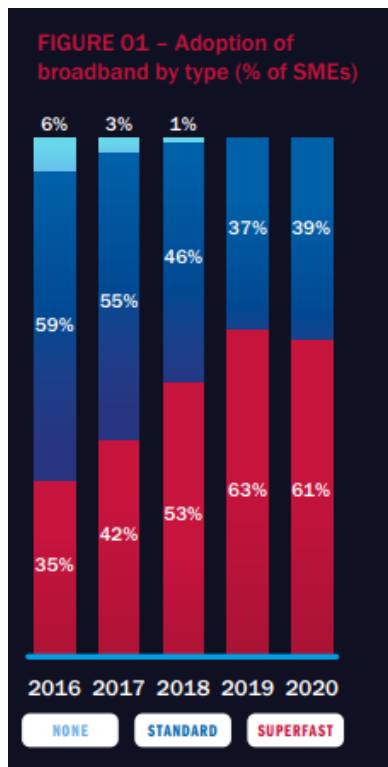
Furthermore, a further Welsh SME, 'The Wales Centre for Advanced Batch Manufacture' (CBM) employs advanced engineering technologies to drive innovation across a range of industrial sectors. Their research and services cover reverse engineering and 3D scanning services. CBM's scanning technologies are used within a variety of sectors ranging from measurement and inspection services to reverse engineering and digital preservation of heritage artifacts (Alport, 2022). For SMEs who may not have the financial infrastructure or expertise to invest in such technologies in house, CBM's portable systems allow them to undertake scanning at various premises, promoting industry 4.0 technologies across Wales. Many SMEs would choose to engage with companies such as CBM in order to test the waters in order to explore their readiness to committing to investing in new technologies.

When considering all industry 4.0 capabilities mentioned above, it is evident that many SMEs are not ready and willing to embrace certain technologies due to associated costs. Technologies such as autonomous equipment or additive manufacturing are amongst the most expensive technologies to implement within an organisation. However, SMEs in Wales have been embracing digital technology in order to accelerate their growth for many years. With more than 79% of Welsh SMEs utilising cloud enabled software packages to reduce time, workload and storage by 2016 (Business Wales, 2017). The Digital Maturity Survey for Wales 2020 report confirms that the use of cloud computing services by SMEs continued to increase in 2020 (Henderson et al, 2020). With more than 70% of businesses making use of foundational cloud computing services and fewer businesses reporting using more advanced cloud services.



Henderson et al, 2020

Although the use of foundational cloud computing services by SMEs remained relatively static from 2017-2020, the advanced cloud computing services such as video conferencing increased by 37% from 2017-2020 and 31% from 2019-2020. The uptake of video conferencing by SMEs in the 2020 period was in response to the severe disruption associated with covid-19. The introduction of the Welsh Government's superfast broadband business exploitation programme in 2017 meant that the majority of SMEs had adopted superfast broadband prior to the pandemic, improving their infrastructure for uptake in cloud computing services which was demanded during the pandemic. The results here suggest that SMEs were most likely to report that their broadband services allowed them to respond to COVID-19 by enhanced use of video conferencing, with 71% of SMEs agreeing or strongly agreeing with the statement. Following the improvements in broadband services, 61% of SMEs reported greater remote working of staff and 62% of SMEs said the improvement in broadband services has built their confidence for investing in future business practices.



Henderson et al, 2020

The uptake of digital technologies is highlighted by the increased number of SMEs reporting e-commerce transactions. The proportion of SMEs reporting 76-100% of their sales being online was three in ten in 2020, a 12% increase on 2016 figures (Henderson et al, 2020). It would be interesting to investigate whether this is directly linked to the increase in superfast broadband amongst SMEs or whether it is pandemic related as e-commerce sales were encouraged due to the introduction of national and regional lockdowns in response to covid-19. Following the spike in e-commerce growth in 2020 due to the Covid-19 pandemic, internet retail sales were up 10.8 percent in 2021 compared to 2020, which had seen a much higher increase, at 47 percent, this then dropped by 20% during January 2022 which is likely due to the reopening of in-store shops following the lifting of restrictions.

Majority of SMEs in Wales agreed that improved broadband services had a positive impact on their response to covid-19. Broadband services played a key role in enhancing their use of video conferencing, making it possible for staff to work from home, increasing their use of cloud computing, minimising the decline of sales during the pandemic, assisting the business with returning to pre-pandemic sales levels or moving into new

product/service market (Henderson et al, 2020), justifying the requirement for industry 4.0 technologies.

It is likely that the SMEs who did not employ industry 4.0 technologies before the pandemic are amongst those businesses that ceased trading. Companies that did not implement industry 4.0 technologies prior to covid-19 had a wake-up call as a survey conducted by McKinsey (2021), suggests that these SMEs were the ones struggling during the pandemic but are also the ones struggling to catch up due to pandemic related cash restraints. This research found that 56% of respondents that had not implemented industry 4.0 technologies prior to covid-19, found themselves constrained in their ability to respond to covid-19 in the absence of digital technologies to support them.

However, those companies that did not manage to fully commission their industry 4.0 technologies when the pandemic hit, were also affected. The crisis forced some companies to halt their industry 4.0 investments mainly due to reasons associated with travel restrictions or working from home or pandemic related cash constraints. The requirement for capital expenditure for the implementation of industry 4.0 technologies is the reason why a much smaller proportion of Welsh SMEs are employing digital technologies such as artificial intelligence and additive manufacturing (Henderson et al, 2020). The process of transitioning to industry 4.0 technologies by SMEs is extensive, with the pace of uptake varying between organisations. The degree of maturity of an organisation as well as their culture of innovation will both have a significant impact on an SME's decision to commit to employing industry 4.0 practices. The fourth industrial revolution differs from the previous ones with the fact that it relates to all fields of life (Ślusarczyk, 2018). This means that the industry 4.0 framework processes information and commercialises its exchange between people, people and objects and between objects themselves, limiting the requirement for humanistic elements within operations.

Research conducted by Ślusarczyk (2018), investigated different issues which may influence organisations to invest in advanced technologies. It found that the two most contributing factors were the ability of the new technology to form a foundation for new business models and its ability to integrate with already existing processes. The third most influential factor was the available talent and skills to leverage the new technology within the organisation. The Welsh Government developed a 'Manufacturing Action Plan' (MAP) which highlights six overarching issues which they aim to address as a way of ensuring that the Welsh manufacturing community is fit for the future. MAP was introduced in response to the business disruptions experienced as a result of Brexit and covid-19 and has been prioritised in order to future proof the industry in Wales. The six overarching issues that the MAP focuses on are; equality and diversity, the language and culture of Wales, research development and innovation, data, information and language, public sector procurement and business support.

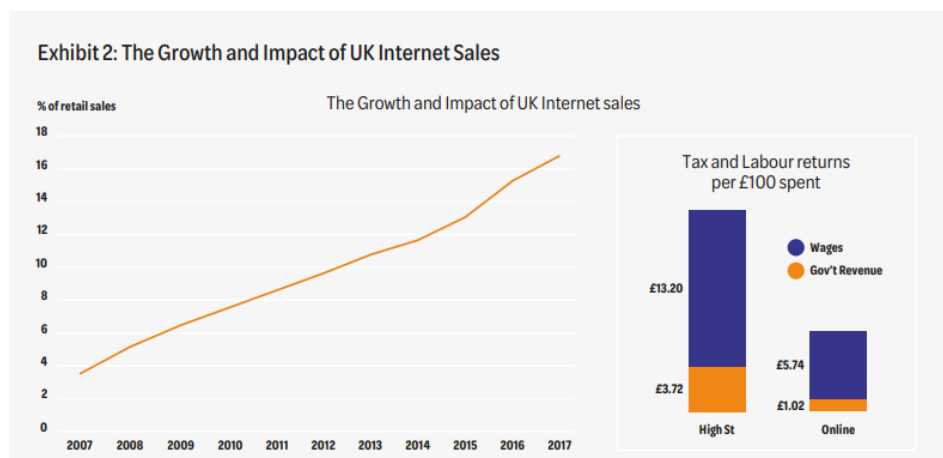
Manufacturing offers a wide range of career opportunities within Wales amongst a variety of SMEs and the Welsh Government are promoting future investments within education and training for manufacturing-based subjects. Having a skilled workforce with a manufacturing expertise as well as leadership and management skills, is more likely to influence Welsh SMEs into transitioning into industry 4.0 technologies. The Welsh Government have also acknowledged that one fundamental issue hindering the future proofing of the manufacturing sector is the lack of research, developments and innovation facilities within the industry. Business Wales services such as SMART innovation, SMART Cymru, SMART expertise and SMART partnerships are services offered by the Welsh Government as part of their innovation programme aimed to support SMEs in their investments into design and manufacturing, research and development as well as introducing new techniques into their processes. Innovation support is currently aimed at delivering on the digital, productivity, Industry 4.0 agendas, along with resource efficiency, decarbonisation and Welsh supply chain resilience (GOV.Wales, 2021). With government support such as this, a small country such as Wales which is predominantly made up of SMEs, has the potential to embrace cutting edge technology into the Welsh manufacturing industry.

However, the UK's future relationship with the European Union (EU) will undoubtedly have major funding implications for Wales. Wales secures most of its EU research and innovation funding from the EU Structural Funds. During the current Programme funding period (2014-2020), the Welsh Government has invested £340m in Research and Innovation priorities. This represents 20 per cent of all EU structural funds allocated to Wales and continues to play a vital role in growing Wales' research capacity and infrastructure. The UK Government's guarantee to sustain these funds following Brexit will be crucial to the development of a Wales 4.0.

On the other hand, the idea of Wales 4.0 leads to more questions being raised regarding its value. Many theorists have been led to believe that employees in countries where industry 4.0 is being employed, will eventually be replaced by robots or machines leading to increased unemployment rates. Digital technologies can be used to augment skills and improve job quality, but they can also be used to deskill and eliminate jobs (GOV.Wales, 2019), which is a smaller scale representation of what happened during the second industrial revolution following the introduction of mass production lines. The Welsh Government's MAP focusses on reskilling Welsh workforces in preparation for new emerging occupations as the prediction is that digital technologies will result in both job displacement and creation. Ultimately, digital innovation will create, destroy and redesign jobs but the pace and scale of this change is unpredictable and more radical and inventive solutions are needed if we are to deliver change at the speed and scale required. Developing fully autonomous businesses may make little commercial sense for companies in Wales when they have

access to a supply of relatively cheap labour. If the cost of that labour increases due to minimum wage legislation or demographic shifts in workforce composition, they may decide on a technological solution such as introducing artificial intelligence.

A further issue which has the potential to affect the Welsh economy is the increase in online sales. With purchases such as those from Amazon or streaming entertainment from Netflix, the UK's spending power is increasingly being syphoned offshore. This means that the retention of wages and tax revenue in the UK is diminishing at a time when we need to spend more on health, education and social security (GOV.Wales, 2019). The increase in demand for e-commerce sales is also slowly shutting down highstreets amongst Wales. The covid-19 pandemic influenced online shopping due to national lockdowns and businesses embraced digital technology to reinvent the highstreets.



GOV.Wales, 2019

It is evident that a small country such as Wales is capable of making headway in the fourth industrial revolution. The case studies mentioned above provide evidence that additive manufacturing and advanced cloud computing are already established technologies within manufacturing SMEs in Wales. It is also apparent that industry 4.0 technologies were vital in Wales's response to covid-19 by providing capabilities to increase number of employees working at home, producing track and trace apps, providing a virtual world for tourism businesses as well as estate agents and allowing businesses to increase e-commerce sales which kept the Welsh economy afloat. Although it can be concluded that Wales would not have responded to the pandemic as efficiently without the use of industry 4.0 technologies, it is uncertain what negative impacts the fourth industrial revolution will have on the economy of Wales. It is inevitable that job losses will occur if Wales continues to introduce artificial intelligence into the manufacturing industry, but it may also contribute to the accelerating economic growth and global competitiveness, putting Welsh industries on the map. Organisations within Wales should take advantage of the Welsh Government funding in order to upskill or reskill employees in readiness for employing industry 4.0 technologies. However, major business disruptions such as Brexit and covid-19 have resulted in considerable unpredictability when it comes to Welsh Government funding. How the Welsh Government chooses to deliver research and development and innovation funding, will influence not only the ways in which Welsh SME's will invest in new technologies but will also shape the future of a Wales 4.0.

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