Digital Skills and the Automotive Sector

State of the market report

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Executive summary

The purpose of this report is to understand the current state of skills and digital skills in the UK automotive industry. It contextualises the development of skills and training in the sector with an historical overview of apprenticeships and other training initiatives. To do so it focuses on a number of relevant issues for the automotive sector, including:

- an overview of Industry and the digital skills landscape in the UK
- an overview of the automotive sector in the UK
- UK Skills and digital skills provision and requirements
- UK government policy approaches
- issues of gender and labour supply
- apprenticeships and digital skills.

The report uses 80 publications consisting of company and association reports, journal articles, presentations, surveys, and white papers. It analyses these works and creates a series of recommendations to guide decision making about future skills training. In particular, the report takes into consideration the issue of Brexit, the decision by the UK government to enact Article 50 of the Treaty on European Union, as a prelude to ending the UK's membership. This has far-reaching repercussions for the automotive sector with its extended, international supply chains, and by extension for digital skills training.

The UK economy and digital skills

To better understand the specific issue of digital skills in the automotive sector it is first necessary to contextualise the broader impact of digital skills on the UK economy as a whole. Digital skills are becoming increasingly important across UK industry. Automation and digitalisation are changing the nature of work. They are transforming the nature of the relationship between sectors previously associated with high-labour intensity, and sectors such as Information and Communications Technology (ICT). The term 'digital skills' has a wide range of interpretations, though broadly it refers to the ability of workers to ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers. While many contemporary definitions focus on lists of key skillsets, there is an understanding that in a rapidly evolving landscape, new challenges and competences are required. This section of the report offers a number of differing definitions. It clarifies how they intersect with concerns over skills gaps and skills shortages, particularly for the engineering and automotive sectors. The table below shows the emerging skills needs for engineering.

Emerging transferable skills across engineering sectors

Mechanical Engineering	Software Engineering	Chemical Engineering	Fourth Industrial Revolution
▪ Software design ▪ Software development ▪ Knowledge and skills in digital and software engineering	▪ Physics ▪ Electro-mechanical systems	▪ Mass and energy transfer ▪ Unit operations ▪ Stoichiometry ▪ Fluid dynamics applied in different ways ▪ Proficiency in regulatory requirements ▪ Technical skills ▪ Regulatory skills ▪ Leadership ▪ Coaching ▪ Change management ▪ Digital skills in programming courses	▪ Programming ▪ Coding ▪ The principles of the Internet of Things ▪ Software testing approaches

Source: Authors' own elaboration

The UK automotive sector

The automotive sector is one of the largest employers of labour in the world. In Europe over 12 million jobs are dependent upon the sector. In the UK, the automotive industry employs approximately 823,000 people across the domestic automotive industry with 168,000 people who work directly in, for example, 8 major premium and sports car manufacturers. In 2018, the UK's automotive manufacturers turned over £82bn. The Society of Motor Manufacturers and Traders, a major employers' federation in the UK, estimates that 20,000 new jobs will be created in the sector by 2030. The UK automotive industry's strength is reflected in the production of 1,519,440 cars in 2018 and the establishment of a 2,500-strong supplier base that employs 82,000 people.

The industry is highly export oriented. More than 80 per cent of the produced vehicles are shipped abroad (1,237,608 million units), accounting for £44bn worth of goods. However, the sector has endured a number of major challenges that threaten its continued importance to the economy. Since the 2008/9 recession, the industry has seen over 100,000 workers leave the sector through retirement, voluntary severance and redundancy. Even though the industry has since undergone a recovery, it has struggled to replace these lost workers. Additionally, the decision to end membership of the EU threatens to incur heavy costs on the supply chain and, potentially, tariffs on exported goods. Digital technologies and associated skills offer a significant opportunity to mitigate some of these challenges in the future. The table below outlines emerging digital skill needs in the auto sector.

Job title and required digital automotive skills

Job title	Examples of required digital skills	Priority
Computer Aided Engineering	▪ Auto CAD ▪ FEA testing ▪ Structural FEA, NVH, AERO CFD, MATLAB Simulink ▪ Software engineering real-time software development (Automotive Council UK 2016b: 25)	High now, medium in 2-5 years
Design Engineer	▪ Using mathematical modelling ▪ Producing ideas into "technical plans for prototypes using computer-aided design (CAD) and computer-assisted engineering (CAE) software" (Automotive Council UK 2016b: 48)	High Critical shortage in West Midlands
Basic Engineering ▪ Mechanical ▪ Electrical	▪ Electrical skills: complex calculations/ diagnostic problem resolution	High
Digital scientist	▪ "Designing digital models of physical systems – requires advanced mathematical capabilities to develop algorithms to translate the real world into digital form" (KPGM 2017a: 22)	Medium: Will gain importance in next years

Source: Authors' own elaboration with data from Automotive Council UK (2016b and KPMG (2017a)

Digital skills and industry in the UK

One of the major challenges facing the automotive sector in the UK is the emergence of digital skills as a key component to future growth and development of the sector. Upskilling and training of the workforce in this area has become a major concern for the sector, but more broadly for the UK economy as a whole. KPMG forecasts that the gross value added in the UK economy would be over £8.6bn, or 0.3 per cent of GDP, if the UK automotive industry were to embrace digital technologies and that digital vehicle manufacturing factories were to become fully digital in the next 20 years. Further, this would mean a cumulative benefit of £74 billion for the UK economy by 2035. Table 1 below outlines emerging skills needs.

In particular, the challenge of introducing smart factories, will require a well-trained workforce to operate and interact with such technology. Smart factories are where machinery is augmented by wireless connectivity and sensors, and are able to control and make decisions related to production and stock. This is often referred to as the Fourth Industrial Revolution, or Industry 4.0. The main drivers of Industry 4.0 are the Internet of Things, the Industrial Internet of Things, Clouds based manufacturing, and smart manufacturing. Data has been used in manufacturing for decades; however, new and disruptive technologies are causing a huge growth in its use.. This includes:

- increased affordability of connected devices and sensors using Radio Frequency Identification (RFID) technology
- the increased sophistication of predictive analytics, cognitive computing, and artificial intelligence
- the increased development of the human-machine interface
- technologies such as 3D printing and intelligent robotics enabling production
- cybersecurity technologies and the blockchain.

However, the UK is only ranked eighth out of 25 nations when it comes to automation and digitisation amongst industrialised nations. One problem raised was the change in status and function in 1992 of polytechnics with a vocational orientation, together with a lack of appropriate apprenticeships throughout the 1980s and 1990s.

Industry 4.0 also has implications for the automotive sector. Cyber-physical systems (CPS) is where the development of software interfaces and services support interoperability between physical and control structures. The automotive sector is the most enthusiastic industry when it comes to setting up smart factories. It has larger investments and higher targets than other industries, for example Formula 1 teams based in the UK utilise advanced real-time modelling and analytics capability. Yet the sector still struggles to attract enough skilled graduates. In part, this is down to the traditional image of the sector, but also because of concerns over job security as companies move their operations to low-cost jurisdictions abroad. There is the issue that far more mechanical than electrical or electronic engineers graduating from university, although the latter are in high demand.

Skills provision and requirements

This section focuses on providing an overview on the current state of automotive skills. It states what the skills requirements are. The automotive sector faces a number of key challenges, in particular:

- a lack of domestic Original Equipment Manufacturers (OEM) and a high dependence on foreign direct investment
- competition for labour with highly attractive and well-paying industries such as finance and IT
- a bad public image, derived from the failed nationalisation of the industry in 1960s and 70s, followed by the numerous job losses and plant closures in the decades following
- political inconsistency regarding support for and strategy related to the sector
- a shortage of STEM (science, technology, engineering, and mathematics) graduates in the UK labour force
- the gender imbalance in the workforce.

Despite these challenges, the sector remains highly productive. Within the past two decades productivity moved from £32,000 to £100,900 worth of output per job. This is generally indicative of well-paid work opportunities and stands in stark contrast to the slowdown in productivity in other major areas of the UK economy (sometimes referred to as the productivity puzzle). Looking at the available pool of workers, in 2016/17 13,620 engineering and technology graduates entered the job market and became professionals, of which 9,740 entered professional occupations. In comparison, the largest group entering employment were 26,120 business and administrative studies graduates. Taking into account other factors such as apprenticeships and other in-work learners, the Automotive Council for the UK anticipates future skills shortages in the sector.

It is anticipated that digital technologies will transform the automotive industry in the next number of years. This will require more workers to have the following skills:

- data security
- core business
- technology specific
- interpersonal
- analytical and research.

Disruptive technologies such as low carbon vehicles, autonomous vehicles and connected cars, will create the demand for these skills in the automotive sector. There are efforts to undertake EU-wide, sector-specific skills solutions and an EU-wide partnership on skills. This includes a Blueprint for Sectoral Cooperation on Skills. The Blueprint seeks to address the mismatches between the automotive industry sectors needs and its education supply chain. However, with Brexit expected in Autumn 2019, it is unclear how this will impact the UK component of the initiative.

Skills and government policies

The response of the UK government to challenges raised by the digital skills shortages and the introduction of disruptive technologies to the UK automotive sector are considered in this section of the report. The 2018 Industrial Strategy of the UK Government includes the establishment of a world-class technical education system to stand alongside the higher education system. It pledges to invest £406m maths, digital and technical education, and establishing a National Retraining Scheme that intends to fund the re-skilling and retraining of adults. The UK Government also has a Digital Strategy in which skills, connectivity, and cyber security are core components, together with digital training. A number of major firms such as Accenture, Lloyd's Bank, Microsoft and the Open University have promised free training on digital skills as part of this initiative. This includes a Digital Skills Partnership, which aims to improve digital skills, both for people and organisations. It brings together public, private, and charity sector organisations to ensure that everyone has access to digital skills training.

In terms of the automotive sector and digital skills, the need for strong digital leadership, the digitisation of apprenticeships, an adoption of learning analytics, and a rise in data-driven decisions was identified. In response, the government has established the Automotive Sector Deal, which comprises the partnership among government and industry. The partnership plan to invest about a £1/4bn to develop and manufacture electric vehicles. The deal reflects the government's industrial strategy that is built on the five foundations: ideas, people, infrastructure, business environment, and places.

Other important government expenditures will be the planned £500m in low-carbon automotive technologies; investments to support the transition to ultra-low and zero emission vehicles, by providing £246m for the Faraday Battery Challenge, and £250m through 2021 to shape the future of mobility. Another relevant policy is the Department for Transport's industrial strategy 'Road to Zero'. This intends to end the sale of new conventional petrol and diesel cars and vans by 2040. Its plan is to substitute them with low carbon and semi-autonomous vehicles with a lower carbon footprint.

Gender gap in the automotive industry

Overcoming the gender gap in the UK auto sector could increase the supply of trained workers in the industry. Only 12 per cent of the people working in engineering and technology jobs are women (47 per cent of the UK workforce is female), which is the lowest value in Europe. In the manufacture of motor vehicle, trailers and semi-trailers only 13.8 per cent of all people working in this field in the UK are women. This is a significant difference compared to the EU average, where 25 per cent of the motor vehicle manufacturing workforce is female. The disparity also becomes apparent when looking at the data on how many females choose STEM subjects. In 2017, just 27 per cent of entries to A levels were in STEM subjects for females, in contrast to 46 per cent of entries for males, and just 21.5% of students for A Level physics are female. This figure has not varied a great deal over 30 years, despite efforts to change it.

A significant issue is the gender pay gap, which the industry will also need to be addressed. In 2018, the gender pay gap in the UK automotive manufacturing (including is close to that in manufacturing overall (men are paid, on average, 20.3 per cent more than women in a similar role) with men paid 22.8 per cent more than women. This gap can occur for a range of reasons: hours worked, experience levels, differing roles etc. However,. it still represents a major opportunity to improve representation in key areas in the industry. This gap presents a major challenge but also potential solution for the UK automotive sector.

Apprenticeships

Apprenticeships have been in evidence in the UK since the medieval period, but became increasingly unpopular during the 1960s and 70s as skills acquired no longer matched skills required in the workforce. The introduction of Modern Apprenticeships in the 1990s sought to address these problems and have seen several reforms and developments since their establishment. In 2017/18, there were 814,800 students training as apprentices in England alone. In addition to apprenticeships, there are T levels, post-16 qualifications which started in September 2020 and are equivalent to three A levels. The provision of skills and apprenticeships is devolved in Scotland, Wales, and Northern Ireland, and in these three nations provision has been aligned with existing, recognised qualifications. New provisions are developed according to the needs of the labour market. In 2015, the government announced that it would create a new tax for large employers, the Apprenticeship Levy, to fund its flagship £3m new apprenticeships policy. The figure below shows the numbers of apprentices in England since 2011.

In the auto sector, more than 1,000 young people started their apprenticeship in 2018, which is an increase of more than 40 per cent compared to the 700 apprentices in 2017. The automotive sector has led reforms of apprenticeships including through developing and piloting the new 'trailblazer' standards, and through the setup of the apprenticeship matching service. The automotive apprenticeship matching service might be one of the approaches to make sure that interested young people obtain an apprenticeship place, even if it is not the case with one of the few OEMs. The service was introduced by the Automotive Industrial Partnership. It offers candidates from the OEMs or other large businesses in the automotive sector for the industry. It retrains new entrants who are qualified for the apprenticeship training programme but who cannot join because there are not sufficient places.

Future challenges, opportunities and recommendations

The UK automotive industry has the chance to lead the development of future technologies by becoming a hub for automotive competence. A number of potential challenges also represent opportunities.

- In times of an aging population and increasing retirement age, the process of digitalisation and automation may be a chance to stem the reduction of the workforce.
- The UK would benefit economically and socially from a disrupted technology such as connected and autonomous vehicles.
- The uncertainty around Brexit poses a major challenge and a high degree of uncertainty for the automotive industry. What has already become apparent, however, is that car manufacturers are withdrawing investments.
- The importance of and the dependence on the European automotive supply chain is expressed in the following statistics 80 per cent of all the imported components come from the EU and 69 per cent of components built in Britain are exported: to the EU.
- Brexit may have serious implications for businesses using just-in-time processes considering that components worth £35m are delivered every day from the EU.

With these issues in mind, a number of broad recommendations can be made here.

- While there are already initiatives and programmes that involve academia, industry and government, the cooperation among policy makers, industry associations, and academic institutions could be more intensive, and strategies better aligned.
- One of the interviewed HORIBA-MIRA experts recommended that policy makers seek assistance from both academia and industry (OEMs and suppliers) in funding and developing educational courses that are matched to the needs of industry.
- The industry needs to take an holistic view to increase the number of engineers with required skills. Increasing the diversity in the automotive industry is one of these aspects that needs efforts from all involved parties.
- The government needs to provide funding for education providers to go into schools and 'demystify' the engineering profession with the aim of making the profession more attractive to women, amongst other measures.
- All actors need to intensify their efforts to get girls interested in STEM subjects from an early age. The automotive industry needs to shift its thinking and project an image of the work it does to attract qualified female employees.
- OEMs, suppliers and industry associations need to convey convincingly that they are genuinely interested in a more diverse workforce. Part of that is to be open for people who want to start a second career. There is a lack of women in the industry and it is not yet common for career changers to get the support they need to gain a foothold in the automotive sector.

1. Introduction

The automotive industry in the UK is a key pillar of the country's economy. The competitiveness of UK's automotive OEM and suppliers depend strongly on their ability to employ highly qualified people. However, there is a skills gap in the UK automotive industry that threatens to widen further in the digital age. This report addresses this shortage of well-qualified engineers. It aims to identify what the current state of skills are, and which automotive and digital skills are required to face the automotive transformation. It also outlines how this transformation provides opportunities for UK manufacturers.

This report reproduces knowledge from existing reviews, and also aims to:

- provide in-depth analysis
- identify developments in automotive skills that many other reports lack
- provide clear recommendations on how to improve the current situation in the sector
- add value for readers, whether practitioners, academics, or students.

The report starts with a contextualisation and introduction of the UK automotive sector. It provides definitions of key concepts and an understanding of digital skills in the industry and the role of these skills in the wider engineering sector.

After the contextualisation, the review examines the skills provision and requirements. It points out what the challenges of the automotive industry are and how skills play a key role in the competitiveness of the domestic car sector. Paragraph 4.2 on the Shortage of STEM graduates illustrates one of the causes of the skills shortage. Paragraph 4.3 on Automotive skills provision and upskiling, and digital automotive skills requirements, form the following sub-sections: analysing (changing) key skills that are essential in the age of digitalisation, automation, and electrification. The sub-section International comparisons focuses on skills initiatives of the European Union rounds off this section.

Thereafter, the section Gender gap in the automotive industry will address the gender imbalance, which is a big problem considering that the UK automotive industry loses an enormous potential due to the small number of female engineers.

The report's penultimate section, Apprenticeships, will provide a history of apprenticeships and shows how industry/association-led initiatives may contribute to improved trainings and upskilling opportunities, which take the changes in the sector into account and better prepare apprentices, as well as existing workers and managers for more demanding skills requirements. Also, this section will examine planned government policies and action plans.

The review's last section offers an outlook on Future opportunities and challenges. The chances are particular in digitisation and electrification, and industry-government cooperation. The sub-section on Brexit epitomises a significant challenge for the industry and intends to understand potential negative and positive impacts of Brexit on the skills provision in the UK automotive industry. The report concludes by giving recommendations about initiatives that may improve the currents skills level in the industry.

To summarise:

- This report provides a contextualisation of the UK automotive sector & defines key concepts that are relevant in the digital age
- It examines the sector's challenges, the provision of automotive skills and skills shortages
- The review outlines the skills requirements by providing details about the skills that are needed for the automotive transformation
- It illustrates why the gender gap is a competitive disadvantage for the industry and identifies initiates to tackle the gender imbalance
- This report indicates the importance of apprenticeships as a building block of the sector's future success
- It discusses the opportunities and risks (e.g. Brexit) for the industry
- It concludes with an overview of recommendations

2. Methodology

This review was carried out between June and August 2019. Over 80 publications consisting of company, consultancy and association reports, journal articles, presentations, surveys, and white papers were identified and analysed. The focus of these reports was on the current status of the automotive sector, in particular, the challenges around skills and digital skills in the industry. The focus of the review was the UK, however documents with a wider perspective (e.g. papers published by the EU) were included, too.

Three semi-structured interviews with industry experts and the automotive engineering and development consultancy company HORIBA MIRA were conducted. These interviews were complemented by surveys that were sent to people with many years of experience in organisations such as Jaguar Land Rover, SMMT, and the Automotive Council UK. The participants were asked about their perspective on skills and digital skills in the automotive industry.

In addition, case studies have been used to demonstrate and clarify some of the issues which have arisen in the sector in relation to skills. They offer a specific insight into these core issues and are used throughout the report.

3. Economy and digital skills

This section provides an overview on the economy and digital skills and it divided into four sub-sections:

- Context: Outlines the context of digital skills and provides key definitions
- Introducing the automotive industry: Presents key statistics on the UK automotive industry
- Digital skills and industry: Provides an overview of the problems surrounding the digital skills shortage
- Engineering and digital skills: Examples about importance of digital skills in mechanical and software engineering

3.1 Context

Digital skills are becoming of increasing importance across industry, and this includes within the automotive sector. Automation and digitalisation are changing the nature of work, and digital skills are an increasingly important component in sectors such as engineering and the automotive industries. Likewise, digitalisation is transforming the nature of the relationship between sectors previously associated with high labour intensity, and sectors such as Information and Communications Technology (ICT), which do not have an obvious or immediate connection with areas including manufacturing, but which now see the lines between these activities blurring.

These skills are influencing sectors other than the automotive sector and the demands and requirements of these sectors are changing. To better understand digital skills in the automotive sector it its necessary to understand digital skills more generally, and in particular those which intersect with the automotive sector such as in ICT. These represent how the lines between different disciplines and skillsets are being blurred, with the automotive sector increasingly utilising and requiring digital skills, and ICT companies increasingly having a role in the automotive sector.

Digitalisation can be seen and has benefits across the value chain of the manufacturing sector, as KPMG (2017a: 8) stated in the following:

"Digitalisation technologies […] have had beneficial impact on suppliers, OEMs and end-customers. While some technologies have more focused applications (e.g. robotics on production), others such as cloud computing, analytics and cybersecurity are progressively leading to an unprecedented sharing of information and new applications across the value chain."

Definitions

Before continuing, it is important to define what is meant when discussing digital skills. There are numerous definitions of digital skills or digital literacy which may come in the form of academia, government, or industry perspectives. There is much discussion of this in the UK Government. These definitions often come in the form of lists of digital skills which are advantageous or necessary for employers to have in the workplace, and may not so much a definition of digital skills but the skillsets themselves. UNESCO (2017: 23) describe how "current definitions of digital skills and competencies are related closely to recent ongoing trends in ICTs. New devices, applications and genres of technology will often involve altered, sometimes additional, skills and competencies". In this sense, there is much of the discussion surrounding definitions that is related less to defining what digital skills or digital literacy actually are, as much as describing different – and changing – sets of competences. Some of these digital skills can include a framework to explain the different skills. Others define these skills according to different skill levels, such as beginner, intermediate, and advanced. Indeed, Nesta provide suggestions as to how to actually come up with a definition for digital skills based on the numerous reports and frameworks available.

Ecorys UK (2016) define a number of key concepts. Skills are defined as "the ability to perform a task to a predefined level of competence (Ecorys UK 2016: 8) and skills gaps as "deficiencies in the skills of an existing workforce, both at the individual level and overall, which prevent the firm or a sector from achieving its business objectives (linked to problems with skills inside the business)" (Ecorys UK 2016: 8). Skills shortages are defined as "recruitment difficulties caused specifically by a shortage of individuals with the required skills in the accessible labour market (linked to problems with skills outside the business – in the general workforce)" (Ecorys UK 2016: 9) and the distinction between tech and digital as being that…

"…'tech' is used in relation to sectors that cover companies whose focus is on IT software and services, covering telecoms services, computer games, IT and telecoms manufacturing; 'digital' technology companies work across various sectors from software development, e-commerce and telecommunications through to advertising and marketing and financial services" (Ecorys UK 2016: 9).

Whilst much work, therefore, does not provide a definition of digital skills or literacy, rather focusing on key skillsets which may be necessary, there are however some definitions that have been in use since for some two decades and since digital literacy became a focus of academic attention. This is outlined further by Lankshear and Knobel (2006) who discuss the different types of definitions of digital literacies and further provide some examples of these.

[1] Nesta is an innovation foundation, formerly NESTA (the National Endowment for Science, Technology, and the Arts) and was established in 1998 with endowment from the UK National Lottery. In 2012, it became an independent charity.

One of the most common definitions comes from Paul Gilster in his book Digital Literacy. As Gilster (1997: 28) observes, "digital literacy doesn't mean we have to become programmers or learn to puzzle out long lines of computer code." Rather, he (1997: 1-2) explains that:

"Digital literacy is the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers. The concept of literacy goes beyond simply being able to read; it has always meant the ability to read with meaning, and to understand. It is the fundamental act of cognition."[2]

There are, therefore, a variety of different ways of understanding digital skills and digital literacy (refer to Figure 1 for an overview of the different definitions). Whilst many contemporary definitions focus on lists of key skillsets, there is an understanding that in a rapidly evolving landscape, new challenges and competences are required.

3.2 Introducing the automotive industry

The global automotive industry is in state of change. The development of alternative propulsion systems , changing mobility behaviour and disruptive innovations lead to major changes, affecting the British automotive sector equally. These changes are reflected in the development of electric cars, "digitalisation across the value chain" (Ernst & Young (E&Y) 2016: 1), autonomous and networked cars and digital mobility, as well as in the multitude of new players entering the automotive industry. In Europe, the automotive industry provides jobs for 12 million people and "has an important multiplier effect in the economy", i.e. it is of great importance for upstream (e.g. steel, chemicals) and downstream (e.g. IT, services) industries.

Figure 1. Definitions of digital literacy, skills, skills gaps, and skills shortages

Summary of key definitions:
▪ **Digital literacy:** "The ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers. The concept of literacy goes beyond simply being able to read; it has always meant the ability to read with meaning, and to understand. It is the fundamental act of cognition." Gilster (1997: 1-2) ▪ **Skills:** "The ability to perform a task to a predefined level of competence." (Ecorys UK 2016: 8) ▪ **Skills gaps:** "Deficiencies in the skills of an existing workforce, both at the individual level and overall, which prevent the firm or a sector from achieving its business objectives." (Ecorys UK 2016: 8) ▪ **Skills shortages:** "Recruitment difficulties caused specifically by a shortage of individuals with the required skills in the accessible labour market." (Ecorys UK 2016: 9)

In 2009, the report of the New Automotive Innovation and Growth Team (NAIGT) on the future of the UK automotive industry indicated that the advanced manufacturing sector has become more competitive after years of problematic labour relations and quality issues. The NAIGT report provided a thorough review of the UK automotive industry, listed the sector's key opportunities and challenges and provided relevant recommendations that were well received. While the report's authors count labour flexibility and productivity as strengths of the industry, a "shortage of sufficiently skilled workers" (NAIGT 2009: 6) was considered a great challenge. The uneven digitization in the UK is further discussed as a challenge for UK productivity by Bughin et al (2018). A challenge that, according to the Automotive Council UK (2018: 2), remains "stubbornly unresolved" and endangers, if not addressed, the "long-term sustainability" of UK's automotive industry that is one of the economy's most important sectors and a key contributor to the country's GDP. It employs 823,000 people across the domestic automotive industry with 168,000 people who work directly in, for example, 8 major premium and sports car manufacturers. The Society of Motor Manufacturers and Traders (SMMT) estimated that 20,000 new jobs will be created in the automotive sector by 2030 (SMMT 2019c). Given a shortage of skilled workers, this figure is realistic, and it will be important for the industry to hire these highly qualified people to remain competitive. A reason for this shortage is, for example, as Nigel Stein stated, that "through the recession over 100,000 people left the industry through retirement, voluntary severance and redundancy, and as the industry has recovered, few of these people have chosen to return" (Automotive Council UK 2016b: 4).

In 2018, the UK's automotive manufacturers turned over £82 billion in a highly volatile and competitive environment that is subject to a permanent need of highly skilled labour. The UK automotive industry benefits from strong collaboration between universities and industry and due to labour flexibility and higher productivity – which was in 2016, "40 per cent higher than other manufacturing sectors and 80 per cent higher than the economy as a whole" (House of Commons Exiting the European Union Committee 2017: 2) – the UK car sector can be considered to be "highly competitive" (Automotive Council UK 2018). This competitiveness is connected to the strength of suppliers, whose role and power has changed within the last decades. SMEs play a crucial role in the development of innovations on which OEMs depend on. Their innovation power is reflected in the creation of advanced manufacturing components and modules. Skilled people are needed in Research and Development (R&D) to create more efficient processes and components, however, less for the actual manufacturing steps, which are more and more automated. The growing automation leads to a higher demand along the supply chain for skilled labour and engineers with a cross-disciplinary understanding.

[2] Gilster (1997: 1-2) goes on to describe how "digital literacy likewise extends the boundaries of definition. It is cognition of what you see on the computer screen when you use the networked medium. It places demands upon you that were always present, though less visible, in the analogue media of newspaper and TV. At the same time, it conjures up a new set of challenges that require you to approach networked computers without preconceptions. Not only must you acquire the skill of finding things, you must also acquire the ability to use these things in your life."

[3] Traditional propulsion technologies are cars with internal combustion engines run with fossil fuels such as gasoline or diesel fuel. Alternative vehicle propulsion technologies are, for example, battery driven electric vehicles, hydrogen fuel cell electric vehicles or liquid petroleum gas vehicles.

The former Minister of Skills, Nick Boles, stated that the "UK automotive sector is already an exemplar, leading the way as the most productive of all major European automotive producers" (Automotive Council UK 2016b: 3). The UK automotive industry's strength is reflected in the production of 1,519,440 cars in 2018 and the establishment of a strong supplier base with 2,500 suppliers, which employ 82,000 people (SMMT 2019c). The automotive manufacturing industry in the UK is highly export oriented, as shown by the fact that more than 80% of the produced vehicles are shipped abroad (1,237,608 million), which accounts for £44 billion worth of goods (SMMT 2019c). Figure 2 summarises the previously stated statistics on the UK automotive industry.

The automotive sector therefore has a central place in the British manufacturing landscape in terms of revenue and employment. The implications of digitalisation and digital skills, and the necessity to develop policies both on a governmental and industry level, will therefore be seen throughout this report.

In the following sub-section, the importance of digital skills in industry will be covered, including examples of how digitalisation is being utilised. This includes ideas surrounding Industry 4.0 and the Internet of Things, and how these are affecting the automotive sector.

Figure 2. Key statistics on UK automotive industry

The UK Automotive Industry: Key Statistics

- The automotive industry provides jobs for 12 million people in Europe.
- It employs 823,000 people across the domestic automotive industry.
- 168,000 people work directly in the sector.
- 1,519,440 cars were produced by the UK automotive industry in 2018.
- There is a strong supplier base with 2,500 suppliers, which employ 82,000 people.
- More than 80% of the produced vehicles from the UK automotive industry, 1,237,608 million, are shipped abroad.
- This accounts for £44 billion worth of goods.
- The UK's automotive manufacturers turned over £82 billion in 2018.

3.3 Digital skills and industry

KPMG (2017a) forecasts that the gross value added in the UK would be over £8.6 billion, or 0.3% of GDP, if the UK automotive industry were to embrace digital technologies and that digital vehicle manufacturing factories were fully digital in the next twenty years. Further, this would mean a cumulative benefit of £74 billion for the UK economy by 2035 (KPMG 2017a). This would also increase the competitiveness of the UK automotive industry substantially, especially given efforts being undertaken in digitalisation in countries such as Germany, the USA, and Japan (KPMG 2017a).

These benefits, and the international perspectives brought from countries such as Germany, Japan, and the USA, have direct implications for the automotive sector in the UK, for example, in the West Midlands. Due to the presence of strong big companies such as Jaguar Land Rover (JLR) and GKN Automotive, universities with strong automotive ties, and various research centres (refer to sub-section 8.1 Opportunities (and risks) due to new technologies for a table with research facilities in the region), the West Midlands is a firmly anchored automotive location.

KPMG (2017a: 12) observe that:

"The UK benefits from a diverse mix of manufacturers bringing German, Japanese and US perspectives on digitalisation. The UK motorsport sector has significant real-time simulation and advanced analytics capability and the gaming industry is collaborating with manufacturers to enable new virtual product and process validation techniques. Smart factory demonstrators for example, the MTC (refer to Figure 4 for more information on the Manufacturing Technology Centre (MTC) and Table 5 for a list of facilities in the West-Midlands] in Coventry provide technology demonstration to suppliers."

According to Burke et al. (2017: 2), "a true smart factory can integrate data from system- wide physical, operational, and human assets to drive manufacturing, maintenance, inventory tracking, digitization of operations through the digital twin, and other types of activities across the entire manufacturing network." The authors (2017) however, identify the smart factory as going beyond automation, integrating what is happening in a factory across a broad supply change and interconnected IT/OT landscape, and "can operate within the four walls of the factory, but they can also connect to a global network of similar production systems, and even to the digital supply network more broadly" (Burke et al. 2017: 5). See Figure 3 for a list of five characteristics of a smart factory.

[4] The government responded to NAIGT's report (that was published in May 2009) in November 2009 and supported the recommendation to establish a 'National Automotive Council' that consists of representatives of the Government and key decision makers of the automotive industry. NAIGT's suggested that the Council's tasks would be to "develop, guide and implement a strategic framework for the industry" (NAIGT 2009: 10).

[5] The Automotive Council UK is made up of senior figures from across industry and government, and established in 2009, this is the body which works on dialogue and cooperation between the UK Government and the automotive sector.

[6] Nigel Stein is the Chief Executive of GKN Plc and the Chairman of the Automotive Council

[7] In 2018, the total number of produced vehicles in the UK (including commercial vehicles) was 1,604,328 (SMMT 2019c), which is less than 2017 (total number of manufactured vehicles was 1,744,652). In the same period, the production of engines remained about the same with 2,715,400 in 2018 (SMMT 2019c) and 2,722,325 in 2017 (SMMT 2018b).

Figure 3. Characteristics of a smart factory

Five Characteristics of a smart factory:
▪ Connected ▪ Optimized ▪ Transparent ▪ Proactive ▪ Agile Burke et al. (2017: 6)

This builds on the aforementioned ideas surrounding Industry 4.0. Wang et al. (2015: 3) describe how "the Industry 4.0 expects to vertically integrate the hierarchical subsystems to transfer the traditional factory into the highly flexible and reconfigurable manufacturing system, that is, to implement the smart factory."

Figure 4. The Manufacturing Technology Centre (MTC)

> Manufacturing Technology Centre (MTC) in Coventry is an independent Research and Technology Organisation (RTO), which was established in 2010 and opened in 2011, aims at "bridging the gap between academia and industry – often referred to as 'the valley of death'". MTC Coventry has expanded to include the Advanced Manufacturing Training Centre and the National Centre for Additive Manufacturing. MTC Coventry has more than 700 employees, and more than 100 of the companies which have been helped by the MTC have become members of the Centre.

The automotive sector is, according Capgemini, the most enthusiastic industry when it comes to setting up smart factories, with larger investments and higher targets than other industries. Key findings from a survey of over 320 automotive manufacturers shows that the global auto industry could receive gains in productivity of up to $160 billion a year by 2023 onwards, and that automotive manufacturers expect that by the end of 2022 some 24% of their plants will be smart factories. Examples include BMW, Audi, and Harley-Davidson, all of whom are utilising smart factories to reduce their costs and hours required for production. Despite this potential, however, the automotive sector also has the highest share of struggling smart factory initiative. Nonetheless, The Manufacturer reports that 79% of manufacturers think that their supply chain relationships will be improved by smart factories, and 84% think that smart factories will accelerate innovation and design development.

In the UK automotive sector, there are also direct effects of digitalisation. Many Formula 1 teams are based in the UK and utilise advanced real-time modelling and analytics capability, and there are game developers in the UK who collaborate with manufacturers including the Digital Catapult and High Speed Sustainable Manufacturing Institute (HSSMI). Despite this, many vehicle manufacturers had only initiated pilots in digitalisation and some including SMEs had not even begun digital pilots (KPMG 2017a). Barriers to digitalisation include:

- Lack of knowledge and skills for a digital strategy on a company-wide basis
- Trust between supplier and manufacturer to share data in an electronic manner
- Lack of funding for investment in the case of SMEs

Whilst data has been used in manufacturing for decades, new and disruptive technologies are causing a huge growth. This includes:

- increased affordability of connected devices and sensors using Radio Frequency Identification (RFID) technology;
- the increased sophistication of predictive analytics, cognitive computing, and artificial intelligence;
- the increased development of the human-machine interface;
- technologies such as 3D printing and intelligent robotics enabling production from a digital construct;
- and cybersecurity technologies and the blockchain seeing improvements.

All of these improvements mean that these technologies can be used in real time and the data used digitally to make decisions and inform the industry. Information and new applications can thus be shared across the value chain (KPMG 2017a).

Likewise, AutoCAD (a computer-aided design (CAD) software used by professions such as architects and designers) and other digital modelling software is expected as a skill for the bulk of roles in engineering and as engineering technicians, and designs and models are expected to be built according to this (Burning Glass Technologies 2019). The analytics software company Burning Glass Technologies (2019), in research commissioned by the Department for Digital, Culture, Media and Sport (DCMS), observe how skills in modelling tools including Altium for the design of circuit board, CANape for the design of automotive parts, and MathWorks' Stateflow for the programming of industrial machines can make engineers more valuable to their employers.

According to the Economist Intelligence Unit's Automation Readiness Index, the UK is only ranked eighth out of twenty five nations when it comes to automation and digitisation amongst industrialised nations. One of the areas in which the UK is being held back is lack of digital skills, as reported by Cath Everett in Computer Weekly. One problem raised was the abolition in 1992 of polytechnics with a vocational orientation together with a lack of appropriate apprenticeships throughout the 1980s and 1990s, even though there is now an effort to increase the number of apprenticeships. The Made Smarter Review 2017 provided potential explanations, namely that the "government education policy has resulted in a confusing landscape" and that there is "no overarching body which focuses on digital engineering and represents industrial demands and requirements" (Made Smarter Review 2017: 76-77). In addition, there is the image of a sector which is fairly traditional, and without job security as companies move their operations to low-cost jurisdictions abroad. There is also the issue that there are far more mechanical than electrical or electronic engineers graduating from university despite the latter being increasingly important and necessary.

Considering the increasing importance of EVs, there will be a higher demand for electrical, thermal and chemical engineers who have knowledge of batteries, power electronics, as well as an understanding about the software in EVs. It was observed in the 2019 UK Automotive Trade Report that on UK roads there are currently 195,410 plug-in vehicles out of approximately 35 million cars, and that in 2018 there was a 2.5% share of the new car market in plug-in vehicles with 6% of new car registrations in 2018 being for alternatively fuelled vehicles. The global projections of Deloitte suggest that by 2030 EVs will consist of 21 million units and will make up some 20% of light duty vehicles globally (Deloitte 2019), and Bloomberg projects a market share of 28%. As a result, business models will need to adapt and change, and this includes in the automotive sector in the UK. A HORIBA MIRA expert stated (interview #3):

"It will be incredibly important that OEMs make the transition from mechanical to electronic engineering. Especially when it comes to autonomous vehicles, car manufacturers rely heavily on tech companies and outsource projects [that require digital skills, which some OEMs do not have]. It will be a core challenge for traditional automakers to develop and maintain digital capabilities in-house. When we talk about autonomous vehicles and cyber security, automotive companies need highly skilled software engineers – also in order to have the expertise to protect a vehicle with its connected and complex technologies against cyber-attacks – but these people tend to be attracted by the huge wage structures offered by the likes of organisations such as Google, Facebook, Amazon, or Apple, plus the automotive industry, until recently has never been associated with anything either mechanical engineering."

There is also the importance of ideas surrounding the fourth industrial revolution, or Industry 4.0. These are necessary to describe as concepts before going further. In order to master Industry 4.0, the automotive industry requires employees with digital skills. The main drivers of Industry 4.0 are the Internet of Things, the Industrial Internet of Things, Clouds based manufacturing, and smart manufacturing (Vaidya, Ambad, and Bhosle 2018). First coined as a term at the Hannover Fair in 2011 (Schwab 2016), Vaidya, Ambad, and Bhosle (2018: 234) describe how "the German Federal Government presents Industry 4.0 as, an emerging structure in which manufacturing and logistics systems in the form of Cyber Physical Production System (CPPS) intensively use the globally available information and communications network for an extensively automated exchange of information and in which production and business processes are matched".

The fourth industrial revolution has been widely discussed, including by figures such as Professor Klaus Schwab in his 2016 book, The Fourth Industrial Revolution. Schwab (2016: 12) describes how "it began at the turn of this century and builds on the digital revolution. It is characterized by a much more ubiquitous and mobile internet, by smaller and more powerful sensors that have become cheaper, and by artificial intelligence and machine learning."

Piccarozzi, Aquilani, and Gatti (2018: 2) describe how it "is based on the development of a completely automated and intelligent production, capable of communicating autonomously with the main corporate players" and "on the horizontal and vertical integration of production systems driven by real-time data interchange and flexible manufacturing to enable customized production" (Piccarozzi, Aquilani, and Gatti 2018: 2). According to Motyl et al. (2017: 1502), "Industry 4.0 is formerly known as the fourth industrial revolution, a revolution based on the use of Cyber- Physical Systems – CPS". It is "the intelligent networking of industrial products and processes" (Nagy et al. 2018: 3).

Industry 4.0 also has implications for the skills development in automotive sector, including in cyber-physical systems (CPS) which is where the development of software interfaces and services support interoperability between physical and control structures (Segura-Velandia et al. 2016). This is important, as whilst UK manufacturers expect a 10.8% boost in revenue and savings of 9.3% from Industry 4.0, only 1% are considered digital champions compared to 10% globally, and only 1% have implemented AI, even though 24% see its potential. A KPMG (2017b) report has likewise highlighted the importance of Industry 4.0 for UK manufacturing, and summarised the priorities for the sector in boosting productivity in missing skills in addition to preparing for Brexit and the development of a business regime which supports the manufacturing industry.

The other key concept, related to Industry 4.0, is the Internet of Things, meaning "a worldwide network of interconnected and uniform addressed objects that communicate via standard protocols" (Vaidya, Ambad, and Bhosle 2018: 235).

These concepts will be mentioned throughout this report, including in relation to government policies and developments going forward. In the following section, how digital skills can be more broadly applied in the engineering sector will be outlined.

[8] Deloitte Touche Tohmatsu Limited is a multinational professional services network.

[9] The McKinsey Global Institute is the arm of the global consulting company McKinsey that is focused on research in business and economics.

[10] Engineering UK is not-for-profit organisation working to promote engineering, and working with the engineering community to encourage the next generation of engineers to go into the sector.

3.4 Engineering and digital skills

McKinsey Global Institute's forecast (2018: 23) considers how Industry 4.0 will "disrupt production functions in factories through better analytics and increased human-machine collaboration". In this way, Industry 4.0 and the increasing need for digital skills has an impact in how sectors such as engineering are utilising software.

Software is increasingly important in mechanical engineering and has significant impact on the physical world. In the field of mechanical engineering in software design and testing there are changes in the skills required, with the increasing importance of software design and development. This is especially the case in product segments, and engineers are increasingly finding themselves required to have a knowledge of both mechanical and software engineering, needing the skills to design, model, and simulate products, and have a knowledge and understanding of coding. Engineers of the Fourth Industrial Revolution are going to require knowledge of programming, coding and the principles of the Internet of Things, and software testing approaches.

Mechanical engineers and software engineers also have complimentary skills. Whilst mechanical engineers are increasingly finding that knowledge and skills in software and digital are important, software engineers may not have the full knowledge of the physics or electromechanical systems. In this sense, the two disciplines are complimentary are need each other. Other overlaps might include developing software for the design of mechanical components. Indeed, the McKinsey Global Institute (2018: 23) observe that "the need for physical and manual skills overall in the sector is decreasing at more than twice the rate for the whole economy". The authors of the report further state that, just as the need for manual skills will decline with automation, the need for socio-emotional and high cognate skills including communication and negotiation, adaptability and continuous learning, and leadership, and also the need for advanced IT skills and digital skills, will increase.

In chemical engineering, Kasprzak (2018) suggests skills such as mass and energy transfer, unit operations, stoichiometry, and fluid dynamics will still be relevant, but applied in different ways, and that it is important to have a proficiency in regulatory requirements. As such, both technical and regulatory skills will be important. Further, skills such as leadership, coaching, and change management are also important. Dos Santos, Vianna Jr., and Le Roux (2017) likewise observe the need for students of chemical engineering to have new digital skills, and assess this in relation to programming courses. The McKinsey Global Institute (2017a; 2017b), however, suggested in their Executive Briefing on analytics, AI, and automation that whilst companies are using their capabilities to not just better their core operations, but even launch completely new business models, the majority of companies are only capturing a small portion of the potential value with regards to revenue and gains in profit. Indeed, according to a McKinsey Survey of 2016 which covered over 500 executives who came from companies across the spectrum of industries, regions, and sizes, over 85% said that they with regards to their goals pertaining to their data and their initiatives in analytics, they were only somewhat effective. Yet, despite this, those companies which utilise automation technologies can benefit from opportunities, for example, in the use of robotics, machine learning, and AI. These opportunities and advantages might include labour substitution, improved productivity, increase throughput, improved predictions, outcomes, accuracy, and optimisation, and the increasing new solutions being found. The McKinsey Global Institute (2017) suggests that automation could globally increase growth in productivity by 0.8% to 1.4% per year. Despite this, concerns surround labour mobility in the 'hourglass economy', as middle-skilled occupations face automation whilst the demand for lower skilled jobs increases due to their lack of automation, according to the organisation Engineering UK (2018) . Further, where skills shortages were occurring, manufacturing companies were increasingly looking to automation to fill those gaps (Engineering UK 2018).

Table 1. Emerging transferable skills across engineering sectors

Mechanical Engineering	Software Engineering	Chemical Engineering	Fourth Industrial Revolution
▪ Software design ▪ Software development ▪ Knowledge and skills in digital and software engineering	▪ Physics ▪ Electro-mechanical systems	▪ Mass and energy transfer ▪ Unit operations ▪ Stoichiometry ▪ Fluid dynamics applied in different ways ▪ Proficiency in regulatory requirements ▪ Technical skills ▪ Regulatory skills ▪ Leadership ▪ Coaching ▪ Change management ▪ Digital skills in programming courses	▪ Programming ▪ Coding ▪ The principles of the Internet of Things ▪ Software testing approaches

Source: Source: Authors' own elaboration

4. Skills provision and requirements

This section focuses on providing an overview on the current state of automotive skills and states what the skills requirements are. It is structured the following way:

- **Challenges of automotive sector to access skilled labour:** Outlining the issues of the sector and reasons why it is a challenge to hire well qualified labour
- **Shortage of STEM graduates:** Providing details on the number of graduates in engineering and technology and what the implications are of a lack of STEM graduates
- **Automotive skills provision:** Providing details on the number of available engineers and upskilling possibilities
- **Digital Automotive skills requirements:** Examining what the digital skills requirements in the UK automotive industry are and stating the sector's skills shortages by, for example, pointing to the importance of interface skills
- **International comparisons:** Providing examples from other countries and EU-wide sector-specific skills solutions.

4.1 Challenges of automotive sector to access skilled labour

Though the UK automotive sector is competitive and may be able to play a crucial role in the automotive transformation in future, there are several challenges and circumstances that make it difficult for the automotive industry to attract talent. For example, there is a lack of domestic OEMs and therefore a high dependence on the plans and investments of foreign automobile manufacturers. The country's biggest automotive manufacturing plants are owned by foreign MNCs such as Honda, Nissan, Toyota, and Vauxhall (belonging to Groupe PSA). This means that often R&D departments are based at the headquarters abroad and the development of components, that require highly skilled labour, does not take place in the UK. Holweg, Davies, and Podpolny (2009) cited in their report a senior decision maker that it is often top-level research that attracts skilled engineers; however, the OEMs rather do not conduct it in the UK. Therefore, the fact that so many of the OEMs and suppliers are global players "who can invest wherever they choose" reinforces the aspect that the "level of […] skills will have to be competitive and globally renowned" (NAIGT 2009: 55). Honda is such a global player that produces with its 4,000 employees 11% of all cars in the UK. In early 2019, the company announced their plans to close the plant in Swindon in 2021. Thereby, the uncertainty around Brexit is only one factor, another one is the trade agreement between the EU and Japan that concerns Nissan, Honda and Toyota – which together employ 14,000 people and produced 48% of all cars in the UK in 2018. This deal "reduces the economic barriers to manufacturing cars in Japan and importing them to the EU" (Rhodes 2019) with the consequence that the Japanese producers could no longer see the necessity of having automobile plants in the UK.

A challenge all automotive manufacturers and suppliers have to face is that the sector competes with highly attractive and well-paying industries such as finance and IT. Though, the OEMs are "strong consumer brands [with] highly developed Employee Value Propositions (EVPs)" (Automotive Council UK 2018: 7), the fact that sectoral boundaries blur - considering that the automotive industry of the future will require similar skills like, for example, the tech sector – could rather be a disadvantage for the car industry. Companies such as Amazon and Google already provide software for automotive companies and it is expected that they extend their business in the upcoming years (Wayland 2019; Windsor 2019). Therefore, highly skilled people with an automotive interest do not necessarily have to work in the (conventional) car industry anymore. Moreover, IT and finance companies do not only pay high salaries, they are often based in London that attracts skilled, young people from all around the country. Therefore, the geographical location of automotive manufacturers may not be a factor that necessarily speaks for the automotive industry.

A problem that does not exist in this form in other countries, for example in Germany, is that the automotive industry still has a bad image in the public perception. Beverland, Nielsen, and Pryce (2015) refer to the 'British Leyland' perception when explaining why many people, including many policy makers, associate the UK car sector with dirtiness, inefficiency and bad labour relations, rather than with high tech and competitiveness. Livesey (2013) examined in his report Public images of manufacturing in the UK: the current situation and future prospects how, for example, pupils and students perceive the manufacturing sector. In the conducted survey, 40% of secondary age students perceive the sector as 'boring' and "younger respondents [had] a lower level of agreement that manufacturing demands high skills" (Livesey 2013: 14-15). However, Livesey (2013: 8) noted critically that there is the "established policy narrative that there is a serious problem with the image of manufacturing in the UK", but policy publications "do not explicitly provide details of the evidence base".

A challenge for the UK automotive industry – one that experts have identified as a weakness compared to other nations such as Germany, France and the USA – is a certain political inconsistency regarding their support for and strategy on the automotive sector. However, one of the interviewed HORIBA MIRA 's automotive experts (interview #1) saw in it a chance that policy makers may allow some leeway regarding the formulation of strategies new technologies:

"Policy is really important. […] At the moment technology is moving so fast that some of the implications are not yet understood. Nobody knows how to solidify certain concepts into regulations. I think what the UK government is doing in terms of a loose regulatory approach is a good way in certain senses, because it means we grow and learn together…"

[11] An independent vehicle engineering and development consultancy based in Nuneaton, Warwickshire which provides engineering, research and test services for the automotive, defence, aerospace and rail sectors; formerly the Motor Industry Research Association.

The NAIGT named changing ministers and a lack of understanding how the sector works as factors that contributed to an insecurity about the (seriousness) of governmental plans. According to the NAIGT report, research councils are underfunded due to "lack of government interest in the sector" (NAIGT 2009: 58). A more recent automotive sector report from 2017 named "government investment in research and development" as an area where the "UK is viewed as being less competitive" (House of Commons Exiting the European Union Committee 2017: 1).

Finally, there is another major challenge that the automotive sector has to face, namely the gender imbalance in the workforce. It is a traditional problem in the automotive industry that there is a low proportion of female employees. That results into a high loss of talent considering that only 12% of all engineers and technicians are female compared to 47% of the working population (Engineering UK 2018: 13). The challenges of the gender imbalance will be explained in more detail in section 6 Gender gap in the automotive industry and initiatives that aim to tackle the issue will be introduced. See Figure 5 for a summary of challenges of the UK automotive industry.

Figure 5. Challenges of UK automotive industry

Summary of challenges of UK automotive industry
Major challenges: ▪ Dependence on foreign OEMs: E.g. Brexit/trade deals impact strategic decisions ▪ Competition with other sectors: E.g. IT and finance sectors pay high(er) salaries ▪ General lack of STEM graduates: Not enough pupils choose STEM subjects ▪ Lack of female workers in male dominated industry: 15% of all engineers are female ▪ Lack of political stability & governmental support
Minor challenges: ▪ Geographical disadvantage: Car companies located outside of metropole London ▪ Image problems: E.g. younger generation perceives car industry as dirty

4.2 Shortage of STEM graduates

It has been stated in several reports that one of the reasons for the great challenge to recruit engineers is that not enough young people opt for STEM subjects (Automotive Council UK 2016b; Engineering UK 2018). While the willingness of young people aged 11 to 19 year to "consider a career in engineering has risen from 40% in 2013 to 51% in 2017", there is a lack of qualified personnel to teach STEM subjects (Engineering UK 2018: 1). According to the Engineering UK report, there is no lack of initiatives; it is rather the opposite, there are too many programmes that may confuse schools, which struggle to navigate through these programmes to find the most impactful ones. The Automotive Council UK and the Department for Business, Energy & Industrial Strategy (BEIS) (HM Government 2018: 5) stated in their report to the first Automotive Sector Deal that an additional £406m will be invested "to address the shortage of science, technology, engineering and maths (STEM) skills". Schemes such as the Art of Manufacturing or the Industrial Cadets may be part of the solution by helping to inspire young people for technical topics and possibly take away their prejudices. Various governmental departments such as the Department for Transport (DfT) provide and support STEM apprenticeship programmes and organisations such as the Royal Academy of Engineering develop campaigns to promote engineering topics and programmes to young people (Royal Academy of Engineering 2017). An increased popularity of STEM subjects may then increase the number of engineering graduates. Currently, less than 10% of all the students in the UK graduate in the areas of engineering, manufacturing and construction (Automotive Council UK 2018).

The Royal Academy of Engineering (2017: 4) stated that the lack of "skilled technicians is a serious threat to the UK's engineering competitiveness" and proposed activities such as the Engineering Talent Project (ETP), the connection of STEM teachers, as well as 'Engineering Leaders Scholarships' (aiming to support undergraduates in UK Higher Education Institutions) to close the STEM skills gap. The Automotive Industrial Partnership for Skills (AIP) is an example of a multi-stakeholder initiative that has the objective to attract young people for a career in the automotive sector, as well as to upskill people already working in the industry. Furthermore, the AIP sees its tasks in tackling "tackle critical skills shortages as the sector grows and evolves" (HM Government 2018: 10). Sub-section 7.3 Apprenticeships and the automotive industry will provide more information on the role of the AIP.

[12] The Royal Academy of Engineering is the national academy for engineering and technology in the UK, including a mixture of business and academia, which works to use the expertise of its fellows to advise the Government and prioritise engineering.

According to the Higher Education Statistics Agency, the total number of students enrolled in engineering and technology subjects was 164,975 in 2017/2018 (slightly less with 165,155 in 2016/2017). 31,9% (52,635 students) of these students were from non-UK countries, of which 39,895 students were from Non-EU countries (HESA n.d.). The number of non-UK students above the undergraduate level is even higher: According to Engineering UK, 2/3 of all engineering students "at taught and research postgraduate levels" in the UK come from the EU or non-EU countries (Engineering UK 2018: Foreword II).

These numbers might mean that it becomes more difficult to provide certainty (regarding the laws on entry and stay) for highly qualified foreign engineering and technology students in times of Brexit. Current strict visa regulations for non-EU students have already noticeable consequences for automotive companies and create a barrier to fill the skills shortage. Associations, governments and local initiatives therefore do well to promote STEM courses and trainings. Thereby, they are also able to also address the problem that many young people are unaware of the extent to which existing apprenticeships and training programmes can provide a solid and successful career path. It will be an important success factor that industry and government are able to fill apprenticeship positions (see section 7 Apprenticeships for more details), which will be the case if young people consider those as an option to acquire skills that will be relevant in the automotive transformation. In this context, it is also important to recognise that constant change requires a willingness to constantly expand and test skills.

Industry initiatives such as the Nissan Skills Foundation may help to get young people excited about STEM subjects. Since 2014, more than 30,000 children from the North-East Region (Nissan UK is based in Sunderland) could experience automotive manufacturing by various activities (for example, interactive workshops).

4.3 Automotive skills provision and upskilling

The productivity of UK automotive industry surpassed the one of the broader manufacturing and overall UK economy by a factor of 1.9 and 2.8 respectively. Within the past two decades the productivity moved from "£32,000 to £100,900 worth of output per job" (SMMT 2019d: 9). The rather high productivity in the UK automotive industry goes against the trend of a generally weak productivity performance of the British economy, also referred to as the productivity puzzle. In order to keep the productivity level high, the automotive sector needs a constant supply of a highly skilled workforce. However, the recent development shows a decrease of productivity by 2% in 2018 compared to 2017. The Automotive Council UK stated in its report The International Competitiveness of the UK Automotive Industry (2018: 5) that "Government and industry have developed successful programmes to increase availability of skills in the automotive", however, in the same breath pointed out that the provision of skills is perceived as a weakness of the domestic automotive sector compared to other nations.

Looking at the numbers of graduates provides some clarity about the shortage of engineers. In 2016/2017, 13,620 engineering and technology graduates entered the job market and became professionals, of which 9,740 entered professional occupations. In comparison, the largest group entering employment were business and administrative studies' graduates with 26,120 leavers (HESA n.d.). A much larger number of young people are in apprenticeships. In 2017/2018, 59,000 young people began engineering and manufacturing apprenticeships (Powell 2019). In the same period, there were around 94,000 current apprentices in England. While the ratio between learners (provision types: higher education, apprenticeships, and non-apprenticeships) and workers already in the job moves between above average and well above average in most parts of the country, the situation in the West Midlands looks more dramatic: The ratio is well below average for all three provision types. In other words, there will be a shortage of skilled workers – a mismatch between the number of workers available and the number of posts to be filled (Automotive Council UK 2016a).

For those already employed in the automotive industry, there are various possibilities for upskilling. The Automotive Council UK's report (2016b) identified upskilling of the existing work force as an important factor for future competitiveness of the local automotive industry. Current employees have to learn new skills (leadership as well as technology-based skills) to keep pace with the technological development and changes in industry. In a more recent report, the Automotive Council UK (2018: 5) stated that challenges such as electrification, automation, digitalisation of production processes increase the need for retraining of the existing workforce. The ProLead Management and Leadership Programme is an example for an

[13] The Nissan Skills Foundation is initiative which aims to encourage young people to take up STEM subjects and offer insights into careers in advanced manufacturing and engineering which was launched in 2014.

[14] A main reason why productivity fell by 2% in 2018 compared to 2017 is the lower demand for cars in big markets such as China and the EU, as well as a lower demand for diesel cars (due to stricter regulations and the environmental impacts, which became better known to the public after the Volkswagen emission scandal was uncovered in 2015).

upskilling activity that builds on an existing base. ProLead's key feature is the combination of existing qualifications and management and technical knowledge that is tailored to the automotive leaders. Dr Farrall, Head of Apprentice and Associate Training at BMW, was cited in a case study conducted from the Automotive Industrial Partnership in the following way:

"The training is aimed at first line disciplinary manufacturing leaders who have formal responsibility for around 50-60 people. It is a big job but those in the role have often had little or no formalised training until now. Yet this is a critical management level – it is the first position where the buck stops with them."

This programme is "partly modelled on the German well established and highly valued Meister qualification" and resulted from a collaboration of BMW and JLR and aims to prepare existing managers for more complex tasks and leadership responsibilities.

NAIGT's report (2009) reflected a certain dissent among interviewees regarding the positions in which there is a shortage of skilled labour; whether it is the middle management, engineers or even blue-collar workers. However, there did not seem to be any ambiguity regarding the lack of secondary school graduates, who choose an engineering career, as the most talented graduates seem to "accept offers from the financial sector rather than from the manufacturing one" (NAIGT 2009: 31). Moreover, the automotive industry does not only compete with the finance sector for talents, but also with the IT industry, whose companies such as Facebook, Apple and Google also target graduates with a STEM background and often offer more lucrative salaries.

4.4 Digital Automotive skills requirements

The skills requirements for employees in the UK automotive sector will change in the upcoming years due to the automotive transformation caused by new technologies, digitalisation and "blurred industry boundaries". While the automotive sector has always had a high demand for engineers and people with a STEM background, it now also needs people who possess interface skills and are comfortable to deal with high degree of cross-disciplinary complexity. This includes the interaction with experts from other disciplines (required to implement innovations) and the ability to capture the digital changes in the industry.

It is therefore of paramount importance that the UK automotive industry continues to be innovative, developing and deploying the latest technologies in order to meet both its own expectations to be a leading sector and the government's regulatory plans. In a PWC report from more than 10 years ago, the former head of the European Federation for Transport and Environment, Joe Dings, stated that "regulatory pressure may lead to innovations we otherwise would not see" (PWC 2007: 116). Now, more than 10 years later, it can be said that there was some truth to the testimony (refer to 6.2 Government policies on automotive skills for more details on governmental regulations, strategies, and plans).
In 2016, McKinsey & Company stated in their report (2016: 3) that there will be a major transformation of the automotive industry in the next years due to disruptive technologies along with the consequences of sustainability policies and "changing consumer preferences around ownership". Although there is still much uncertainty as to what the industry will look like in 10 years' time, it is already clear that digitalisation and electrification trends will have a major impact on skills requirements and apprenticeship programmes, considering that so far skills that combine a digital understanding of the car of the future with classic engineering capabilities have played only a limited role. For the automotive industry in the UK, it is crucial to hire and develop talents in order to stay competitive and not to lose touch with this transformation. The domestic automotive industry has good prerequisites with its labour productivity and the flexible labour market, however the NAIGT identified in its report (2009: 26) that the industry is "fragile due to a continued loss of scale, and the danger of 'supply chain hollowing out'". This referred to the "loss of high-value jobs in the automotive supply chain" (NAIGT 2009: 13) to other countries within Europe and also outside. Various initiatives, such as the Long-Term Automotive Supply Chain Competitiveness programme (LTASC), were set up in the last years, supported various suppliers and contributed to an increased productivity of the supply chain. However, 10 years after NAIGT's report, it still remains a problem that companies in the supply chain lose key people to OEMs and struggle, as well as other firms in the automotive sector to hire skilled labour.

In 2012, as reported by Ecorys UK (2016), the Sector Skills Council for Business and Information Technology, E-Skills UK (2012) identified the following five skills sets required of future employees:

- Security skills relating to data security
- Core business sills
- Technology specific skills
- Interpersonal skills, and
- Analytical and research skills

These skills also play a role when looking at Feloy et al.'s (2013) UKCES report, which identified three key technological advances as impacting the skills need of the Aerospace and Automotive industry. These were additive Manufacturing (AM), or, manufacturing products which used digitally-controlled machines, i.e., 3D printing; composites; and plastic Electronics (Feloy et al. 2013; Ecorys UK 2016).

[15] The Meister is an advanced vocational qualification The Meister qualification certifies occupational competence and allows someone to "set up [their] own business in a trade that is subject to authorisation".

[16] The Sector Skills Council for Business Innovation Technology: The former E-Skills UK, then the Tech Partnership, the sector skills council of the UK in information technology; this organisation has now closed.

It is therefore essential for the UK automotive industry to have a constant supply of skilled labour with digital and business skills to take advantage of the growing importance of connected cars and autonomous vehicles (AVs). The described "transport revolution" (SMMT 2019f: 3) towards connected cars and AVs requires people who are highly skilled in the interface topics of automotive engineering and digitalisation. It is expected that by 2030 new business models revolve around shared mobility and connected cars. These (r) evolutions come along with a changing mobility behaviour, an increasing importance of electric and autonomous vehicles and the abrogation of the classic tier 1, tier 2 and tier 3 supplier pyramid. OEMs become more and more integrators of the different components and need to upgrade their workers' skill sets and devote more resources to finding highly qualified personnel to reduce dependence on suppliers and tech-companies. These changes require new job roles such as digital scientists, digital engineers, digital architects, as well as cyber security engineers, who will play a key role in securing intellectual property and to prevent connected cars from cyber-attacks (KPMG 2017a).

Connected cars and autonomous vehicles do not only revolutionise the automotive market, they also change employability demands. In an autonomous vehicle, there are at least 250-300 million lines of codes, which need to be programmed, updated, and monitored. Therefore, programming skills will be essential, for example, applied by engineers specialised on self-driving cars. A positive perception of AVs, connected cars, as well as the benefits of these technologies might help to attract engineers and IT specialists. In 2018, Deloitte's global automotive consumer study revealed that consumers have a positive attitude towards innovations such as autonomous driving. Moreover, consumers show a high willingness to consider buying electric vehicles – once prices will become more moderate and batteries guarantee longer driving times. It also came out that consumers would feel less concerned about "AV technology if they were offered by a trusted brand" (Deloitte 2018a: 4). This shows again the chances for OEMs with a good reputation such as JLR and Aston Martin to play an integral role in this transformation – if they intensify their efforts to hire and train skilled people. However, highly skilled PhD graduates with a multi-disciplinary background – e.g. in engineering, design, passenger experience – stated in conversations that they have problems finding job descriptions that are not looking strictly for engineers, designers or marketing experts. One of the interviewed HORIBA MIRA experts (interview #1) observed the following:

> **"The temptation at the moment is to push people to specialise and actually, you can specialise in a multi-disciplinary way. Currently, if you're a mechanical engineer, you can continue to be a mechanical engineer, if no one has made you aware – school, university, employer – that you can also have complementary skills, like skills in computer science, simulations, games technology that could then be used with the automotive application to help you for your further career."**

In this context it is also relevant to mention the importance of corporate decision makers, who have a clear understanding of skills required in future and are not solely guided by traditional job understandings. This includes personnel managers who often have the task to 'translate' the requirements of a company in job descriptions. According to the survey of the Automotive Council UK (2016b), relevant jobs with a strong demand and a current shortage are in lean manufacturing, basic engineering, design engineering and Computer Aided Engineering. Refer to Table 2 for an overview on required digital automotive skills and the corresponding job titles. However, the Council's report did not consider jobs such as digital architects,

Table 2. Job title and required digital automotive skills

Job title	Examples of required digital skills	Priority
Computer Aided Engineering	▪ Auto CAD ▪ FEA testing ▪ Structural FEA, NVH, AERO CFD, MATLAB Simulink ▪ Software engineering real time software development (Automotive Council UK 2016b: 25)	High now, medium in 2-5 years
Design Engineer	▪ Using mathematical modelling ▪ Producing ideas into "technical plans for prototypes using computer-aided design (CAD) and computer-assisted engineering (CAE) software" (Automotive Council UK 2016b: 48)	High Critical shortage in West-Midlands
Basic Engineering ▪ Mechanical ▪ Electrical	▪ Electrical skills: complex calculations/ diagnostic problem resolution	High
Digital scientist	▪ "Designing digital models of physical systems – requires advanced mathematical capabilities to develop algorithms to translate the real world into digital form" (KPGM 2017a: 22)	Medium: Will gain importance in next years

Source: Authors' own elaboration with data from Automotive Council UK (2016b) and KPMG (2017a)

Skills shortage

It is a characteristic of the automotive landscape that many of the worlds' biggest car producers have plants and offices in the UK, however their headquarters – and with them highly skilled people and decision makers – are located outside of the country. This may be one of the factors contributing to the lack of sufficient 'medium skilled' jobs. However, it is a cross-sector issue that there are many top end and bottom end jobs. It is rather difficult for lower skilled labour to move up, as there is a bottleneck between low skilled / blue collar jobs and more senior/professional management jobs. It is expected that this 'hourglass' trend will "hold for the UK well into the future, with technological advances resulting in the expansion of knowledge-intensive services and ever-increasing demand for highly skilled labour" (Engineering UK 2018: 19). The Automotive Council UK presents a similar assessment in its report on the international competitiveness of the UK automotive industry. It stated how crucial it is to educate, hire and retain highly skilled engineers with "skills in new product and manufacturing technologies", as the automotive manufacturers are "in a global race to design, develop and manufacture the next generation of ultra-low emission, Connected and Autonomous Vehicles (CAVs)" (Automotive Council UK 2018: 19). The problem remains however that there is an "annual shortfall of up to 59,000 engineering graduates and technicians to fill core engineering roles" (Engineering UK 2018: 6).

The Automotive Council UK recommended that the "government and industry should support skills interventions which will be proposed as part of Automotive Sector Deal #2 - towards developing a workforce with skills" (Automotive Council UK 2018: 19) like those described above. Key words in this context are agility (of the workforce), diversity (of skills), and flexibility and creativity in the application of skills. In their report, the Automotive Council UK named the Automotive Trailblazer Group as an example of a group of employers (e.g. JLR, BMW, Vauxhall) that work together "to develop clear standards, courses, and apprenticeships" (2018: 5). There will be more information on the Automotive Trailblazer Group in 8.3. Apprenticeships in the automotive industry.

The Automotive Council UK's report Employers' Views of the Jobs and Skills Required for the UK Automotive Industry (2016) provided an overview on the gaps in skills provision and identified several areas that need improvement for the future. The two most wanted roles are design engineers and product engineers. There is a shortage of skilled people in these roles now and it is expected that this will have a negative impact on the businesses, if these cannot find qualified engineers. Therefore, there will be an ongoing future recruitment demand for people who combine classical engineering skills with the understanding how changing cars meet the requirements of the market. In the complementing report, Assessing Learning and Training Provision Serving the Automotive Industry, the Automotive Council UK (2016a) assessed the learning and training provision and analysed, among others, the recruitment demand within the automotive sector . The result was that there were 6,140 vacancies between October 2014 and September 2015, of which 40% were in the West-Midlands (Coventry and Warwickshire).

The Automotive Council UK (2016a) identified another problem, namely that school leavers lack basic skills required in the industry. The report suggested traineeships to make school leavers work ready. The issue becomes more complex when trying to understand why there are not enough graduates interested in a career in the automotive sector. The Council's report mentioned an issue that has also been mentioned in the sub-section Challenges of automotive sector to access skilled labour and confirmed by interviews led by this report's authors with industry experts, namely that many engineering graduates do not consider the automotive industry as an attractive field and rather choose sectors such as IT and banking.

For specialist car manufacturers, many of which are based in the UK – for example Aston Martin, Bentley, Rolls Royce, Lotus Cars, McLaren – finding suitable personnel is even more challenging. Considering that these producers combine hand-built with highly technological products, the SMMT stated in their UK specialist car manufacturers report that "the broader automotive sector is already struggling to recruit the right skilled people, and for specialist manufacturers the problem is even more pronounced" (SMMT 2017: 11). Especially workers with skills in "advanced engineering, design and electronics" (SMMT 2017: 5) are in high demand.

There is a great demand for people who are skilled in interface work, i.e. workers who are "multi-skilled in all three areas of mechanical, electrical and electronics" (Automotive Council UK 2016b: 16). For the interviewed HORIBA MIRA expert, universities have a duty to recognise the differing challenges of the industry, for example, by abolishing strict disciplinary boundaries between engineering and science programmes. It will become a future success factor that the involved actors understand that people who are skilled in different areas are crucial for the further development of the industry and international competitiveness. In this context fits what Störmer and his colleagues (2014) stated in their UK Commission for Employment and Skills report on The Future of Work: Jobs and Skills in 2030 : "The boundaries between disciplines, such as natural sciences and informatics, are becoming increasingly blurred" (Störmer et al. 2014: 22). Therefore, the future success of sectors such as the automotive industry also depend on networking efforts and "cooperation of industry and research institutions, both inside the UK as well as internationally", as well as the industry's actors' openness towards cross-disciplinary work. The report stated the importance of digital skills in the context of an increasing digitalisation and automation and named trends such as artificial intelligence and its continuing penetration, the relevance of cyber security, and virtual meetings. These developments are as important for the car industry as for other areas. In order to keep pace with these developments, the automotive industry needs people with digital skills and employees who are willing to upskill quickly if the skills are not developed yet.

NAIGT's (2009: 38) referred to the required talents as "ipod generation" and emphasised that the automotive sector needs to undertake efforts in order to attract "computer/systems integration engineers", who would usually not think about a career in the automotive area, or would not have considered that the advanced automotive sector would require people with their qualification background. The increasingly important work in the interface of traditional manufacture and the application of new technologies may help to change the image of the sector and the perception towards an industry that is highly innovative, evolving and a strong pillar of the overall country's economic performance.

[17] https://www.automotiveip.co.uk/wp-content/uploads/sites/7/2016/04/Automotive-Industrial-Partnership-Assessing-Learning-and-Training-Prov....pdf

4.5 International comparisons

There are efforts to undertake EU-wide sector-specific skills solutions and an EU-wide partnership on skills. The New Skills Agenda for Europe, through the European Commission, have launched the Blueprint for Sectoral Cooperation on Skills. With regards specifically to the automotive industry sector, the Blueprint seeks to address the mismatches between the automotive industry sectors needs and its education supply chain. Due to in particular to an ageing workforce, a poor image of the manufacturing sector amongst young people, the diversity of different national education systems and cultures, and an increasing pace of technological change, there is a shortage of skilled workers. The automotive sector is facing a shortage of STEM graduates and faces competition for skilled engineers from other sectors. Research suggests that, according to the Human Capital dimension of the Digital Economy and Society Index (DESI) 2018, the countries in Europe with the highest levels of digital skills were Finland, the Netherlands, the United Kingdom, Luxembourg, and Denmark, whilst Romania, Bulgaria, Greece, and Italy had the lowest scores in this regard.

The Blueprint therefore seeks to:

- promote upskilling and the acquisitions of digital, mechatronic and transversal skills
- develop programmes for inter-generational learning,
- develop innovative educational tools, vocational training, and apprenticeship programmes
- establish long-term cooperation and exchange of good practice among industry stakeholders and research institutes, and education and training providers involved in skills development. This includes at EU, national, and regional levels.

Moreover, the Blueprint aims to:

- develop and implement programmes and schemes to attract and retain young graduates and women
- develop hybrid programmes in vocational education and training and universities, and
- develop awareness raising activities and social media campaigns amongst students.

Skills are of vital importance in industrial policy in order to increase employability, competitiveness, and growth. One of the dangers is that a lack of skills will create a bottleneck, and this is a concern of the European Commission, with particular worries concerning the skills gaps and the mismatches when it comes to digital and high-tech enabling technologies. The European Commission believes that these needs in skills must be better anticipated (see Figure 6 for more information). These digital skills are particularly important for the European Union for the creation of a Digital Single Market. At present, some 44% of citizens in Europe do not have basic digital skills, and some 37% of the labour force, including farmers, bank employees, and factors workers, lack sufficient digital skills.

Figure 6. The European Commission on skills

The European Commission aims…

"…to increase the EU talent pool and foster the acquisition of new skills with a focus on new technologies. High-tech skills and related leadership capabilities are crucial for European businesses large or small. EU actions aim at benchmarking policies, monitoring trends and the supply and demand, scaling up best practices, better focusing funding programmes and incentives, promoting greater professionalism, curriculum guidelines, specialised skills (including big data, the Internet of Things and cyber-security) and multi-stakeholder partnerships in synergy with the Blueprint for Sectoral Cooperation on Skills and the Digital Skills and Jobs Coalition."

Areas of focus include the Digital Opportunity traineeship initiative. This was created to respond to the concerns of over 40% of business in Europe, which said that they had difficulty in finding the right people when looking for specialists in ICT. The traineeship will provide participants with the opportunity to improve specific skills in ICT including in areas such as cybersecurity, big data, quantum technology and machine learning. The initiative also aims to improve digital skills for business including in areas such as web design, digital marketing, and software development. The aim of this is for up to 6000 students and recent graduates to be provided cross-border traineeships between 2018 and 2020.

Those companies which are at the core of the initiative are members of the Digital Skills and Jobs Coalition, although it is not exclusively for those companies which are a part of this. This "brings together Member States, companies, social partners, non-profit organisations and education providers, who take action to tackle the lack of digital skills in Europe." It addresses the need for digital skills in the following four groups:

- Digital skills for all
- digital skills for the labour force
- digital skills for ICT professionals
- and digital skills in education.

[18] This report presented an "authoritative assessment of future challenges and opportunities in the labour market and the implications for jobs and skills" (Störmer et al. 2014: i). The study included the perspectives of stakeholders from the industry, trade unions and academia. Its relevance lies in the analysis of the changing nature of jobs and skills in the next decades in the UK.

In addition to the aforementioned Digital Opportunity traineeship, initiatives in digital skills are shared and promoted by the Digital Skills and Jobs Coalition through the European Digital Skills Awards.

When considering international examples, the McKinsey Global Institute (2017a; 2017b) observes that in the United States of America, the information and communications technology (ICT) sector, media, financial services, and professional services are moving ahead in terms of digital skills, but other industries such as in utilities, mining, and manufacturing, are in the earlier stages when it comes digitalisation. Of the economy of the USA, 18% is reaching its digital potential, France has reached 12% of its digital potential – the average of the European Union – whilst Germany and Italy have reached 10% of their digital potential, whilst countries such as in the Middle East and Brazil capturing under 10% of their digital potential.

5. Skills and government policies

This section consists of the following two sub-sections:

- **Digital policies, strategies and partnerships:** Provisioning governmental initiatives and public private partnerships to tackle the shortage of digital skills.
- **Government policies on automotive skills:** Providing an overview on the specific government policies on skills in the automotive sector with a focus on STEM subjects

5.1 Digital policies, strategies and partnerships

The Industrial Strategy of the UK Government from 2018 has a number of recommendations, including pertaining to digital skills. These include the establishment of a world class technical education system to stand alongside the higher education system, investing (as stated in sub-section 4.2 Shortage of STEM graduates) a further £406 million in maths, digital and technical education, and establishing a National Retraining Scheme that intends to fund the re-skilling and retraining of adults. The scheme's initial investment for digital and construction training is £64m. The Institute for Apprenticeships will a play a role in the coordination and support of new qualifications.

The UK Government has a Digital Strategy in which skills, connectivity, and cyber security are core components, together with digital training. Several major firms have promised free training on digital skills. These include the Lloyds Banking Group, which has promised that by 2020 it will offer face-to-face digital skills training to 2.5 million individuals, charities, and small and medium businesses. Barclays has promised to teach basic coding to 45,000 more children in addition to helping up to one million people with digital skills and cyber awareness. Google has promised to offer five hours of free digital skills for everyone, in particular focusing on boosting digital skills in seaside towns. In addition, coding is being added to the National Curriculum.

The Education Select Committee launched an inquiry into the Fourth Industrial Revolution, and bodies such as the Joint Information Systems Committee (Jisc) have recommended that the Government require a comprehensive digital strategy to prepare students for this. This includes digital elements of the school curriculum, the role of lifelong learning and aiding people to climb the career ladder. This idea of the Fourth Industrial Revolution is important to take into account. Manufacturing is a significant component of the economy in the UK but requires digital skills in order to lead in this area. Jisc recommends "the need for strong digital leadership, the digitisation of apprenticeships, an adoption of learning analytics, and a rise in data-driven decisions." It is suggested that by 2022 there will need to be over 500,000 computer scientists who are highly skilled. The McKinsey Global Institute (2017a; 2017b) suggests that 30% of activities in 60% of all occupations could be automated. The Automotive Council UK recognise that, in the light of automation, the needs and skills necessary in the workforce are going to require a change and urges investment in skills as a long-term investment to benefit the UK automotive sector.

Figure 7. The cross-sector Delivery Groups' priorities

Digital Skills Partnership (DSP) Delivery Groups
"The DSP set up cross-sector Delivery Groups to tackle 4 priorities: ▪ Increase the national coherence of digital skills provision. Develop tools that will help local and national organisations to identify the digital skills needs of the current and future workforce and support individuals and organisations to identify and access relevant training opportunities. ▪ Support the development of Local Digital Skills Partnerships in English regions that can help to deliver targeted digital skills training for local communities and economies with local and national partners. Monitor and evaluate the benefit of their digital skills programmes and create a 'Roadmap' for sharing best practice. ▪ Increase digital enterprise by helping small businesses and charities upskill their employees and increase their digital capabilities so they can take advantage of the productivity gains that technology provides. ▪ Support computing in schools by convening industry and other partners to ensure that teachers have the knowledge and skills to teach the new world-leading computing curriculum effectively." Via the DCMS.

The ambition of the UK Government is to become by 2030 a world leader in the Fourth Industrial Revolution, as reported in the Made Smarter Review 2017. According to the Made Smarter Review, 90% of all jobs across all sector are going to need digital skills within the next twenty years. Workers such as maintenance engineers will need to have skills in both traditional disciplines of engineering and also in tech skills. This includes the UK Government working with the automotive sector as it changes and move forward.

This is therefore a priority for the UK Government, with at least some level of digital skills being required of 82% of openings which are advertised. Indeed, according to the Open University Business Barometer, the digital skills gap could be causing British organisations costs of an estimated £4.4 billion considering fees for long-lasting recruitment, temporary staff, personnel training and retention measures (Open University 2019). As reported in the Manufacturer, CBI and Tata Consulting Services have found that over two thirds of firms in the UK have digital vacancies which have not been filled. As reported, this was foreseen by companies such as IBM, which thought that a lack of skills when it comes to the digital workforce might hinder digital development globally. Deloitte likewise observes that under half of executives think they have the required skills necessary for them to compete and lead when it comes to the digital economy, and more than 75% of the executives who were asked said that they were finding it difficult to recruit people with the digital skills relevant.

[19] Jisc is a not-for-profit membership organisation providing digital skills and services for UK further education, higher education, and skills sectors.

The Digital Skills Partnership (DSP) aims to improve digital skills, both for people and organisations, and brings together public, private, and charity sector organisations so as to ensure that everyone has access to digital skills training (refer to Figure 7 for a better understanding of the DSP's delivery groups priorities). It states as its aim…

"…to improve digital capability across the whole skills spectrum - from the essential skills that help reduce digital exclusion, to the skills workers need in an increasingly digital economy, and through to the advanced skills required for specialist roles."

Together with Local Enterprise Partnerships (LEPs) and Combined Authorities (CAs), the Government is working to help set up Local Digital Skills Partnerships (Local DSPs). This is so as to address digital skills challenges on a local level and "build thriving and inclusive local economies" and is taking place across the country.

In doing so, it helps increase the digital capability of individuals and organisations in England. This includes the DCMS launching six Local Digital Skills Partnerships in regions across England. Three DSPs were set up in Lancashire, Heart of the South West, and the West Midlands in 2018. Another three regions were then selected and Local DSPs are being set up in Cornwall and Isles of Scilly, Cheshire and Warrington, and the South East throughout 2019. Funding has been allocated to these six Local Digital Skills Partnerships so as to employ Regional Coordinators. These are to assist the delivery of targeted training in digital skills for communities so as to benefit businesses across the region. These DSPs are gathering regional data so as to assist Local enterprise Partnerships (LEPs) and businesses to design effective digital skills programmes regionally, and with digital skills provision which can be replicated across LEPs regions. There are also efforts to help older people and those with disabilities gain digital skills in order to help tackle loneliness in rural areas. For further details of the implications of digitalisation in a rural context, please see Appendix I The rural digital economy.

In response to the strong interest which Local Digital Skills Partnerships have received from regions all over the country, the Government is developing a "Roadmap" over the Summer of 2019 (see Figure 8 for five key steps of DCMS' roadmap). This will provide a step by guide regarding how to begin developing the partnership in any particular areas.

Figure 8. Key steps of DCMS' roadmap

The Roadmap consists of five key steps
1. "Convening the partnership
2. Developing the Local DSP strategy and action plan
3. Coordinating the delivery of local digital skills provision
4. Evaluating success
5. Sharing best practice"
Via the DCMS.

There is also the Digital Skills Innovation Fund. Local Enterprise Partnerships (LEPs) and Combined Authorities (CAs) were invited to bid for grants. This is as part of a new Digital Skills Innovation Fund of £1 million. It is aimed at initiatives which assist people, often from disadvantaged backgrounds, take up digital roles. The programmes will run until the Spring and Summer of 2020.

5.2 Government policies on automotive skills

The policies of the government can be summarised in the Automotive Sector Deal, which is comprised of the partnership among government and industry and the plan that both "invest about a quarter of a billion pounds to develop and manufacture electric vehicles" (HM Government 2018: 3). The deal reflects the government's industrial strategy that is built on the five foundations 'ideas', 'people', 'infrastructure', 'business environment', and 'places'.

Within the pillar 'ideas', the government formulated the vision to become "the world's most innovative economy" (HM Government 2018: 4) by following the plan to "further increase […] R&D investment of £2.3bn in 2021/22" and to "raise total R&D to 2.4 per cent of GDP by 2027 (HM Government 2018: 7). However, for the Automotive Council UK (2018: 2), this can just be the start and it demands that "Government should go further" by, for example, "revisiting the generosity of incentive schemes for R&D". Other important government expenditures will be the planned £500m in low-carbon automotive technologies, investments to support the "transition to ultra-low and zero emission vehicles" by providing £246m for the Faraday Battery Challenge (part of the Industrial Strategy Challenge Fund), as well as £250m through 2021 for the development of CAVs to 'shape the future of mobility'.

A major share of the Government's investments in the area 'people' addresses the skills gaps in the STEM subjects (stated in more detail in the sub-section 4.2 Shortage of STEM graduates). Refer to Appendix II for information on the other pillars – infrastructure', 'business environment', and 'places' – of the Government's Automotive Sector Deal.

Another relevant policy is the Department for Transport's (2018: 7) industrial strategy 'Road to Zero' that intends to "end the sale of new conventional petrol and diesel cars and vans by 2040". Though, it is questionable how ambitious (and thus pressuring for OEMs) this target really is, considering that other countries set similar objectives for 2030, it is clear that this will set the direction and shows to the relevant stakeholders that it is now a question of developing and promoting alternative vehicle propulsion technologies. One of the approaches to increase "the supply and sustainability of low carbon fuels in the UK [is] through a legally-binding 15-year strategy to more than double their use, reaching 7% of road transport fuel by 2032" (Department for Transport 2018: 2).

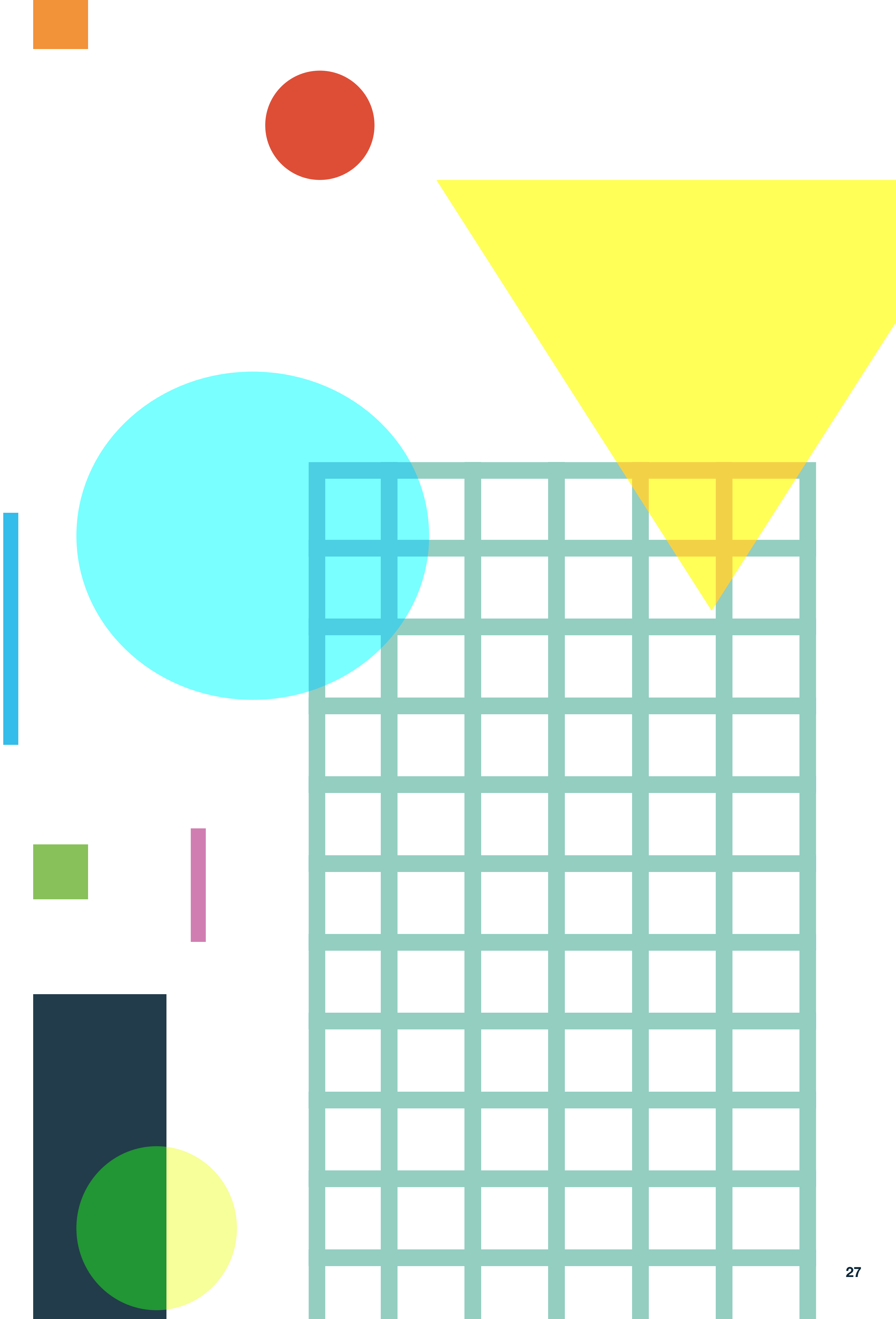
A European policy that may produce results that could be useful for the UK automotive industry is the Development and Research on Innovative Vocational Educational Skills (DRIVES) project. It intends to “deliver human capital solutions to the whole automotive supply chain” (DRIVES 2019a) and is run by a network consisting of universities and alliances from 11 EU countries and will persist beyond Brexit. The SEMTA, an employer-led skills body supporting the engineering and manufacturing sectors, is part of the network that plans to provide skills trainings in the EU automotive sector using data gained from the survey. The project is conducted from January 2018 to December 2021 and is the “Blueprint for Sectoral Cooperation on Skills in Automotive Sector” (DRIVES 2019b: 2). The Blueprint was launched as part of the European Commission’s New Skills Agenda (refer back to Section 4.5 International comparisons for more details).

In December 2018, the Department for Education presented its career strategy for England with the objective to provide better careers advice and guidance. One of the objectives is that by 2020, “schools should offer every young person seven encounters with employers - at least one each year from years 7 to 13 […]. Some of these encounters should be with STEM employers” (Department for Education 2017: 9). Thereby, the Careers & Enterprise Company (CEC), established by the Government in 2014, plays an important in the implementation, as it has a “strategic coordinating function for employers, schools, colleges, funders and providers” and shall offer orientation for young people. Engineering UK (2018: 7) welcomed this initiative as it provides transparency and it allows “the sector to hold the government to account for progress”. Part of the Department for Education’s career strategy is that it requires “schools to give providers of technical education, including apprenticeships, the opportunity to talk to pupils about the courses and jobs they offer” (Department for Education 2017: 13). Sub-section 7.2 Government response to challenges will provide more information on policies on apprenticeships with a particular focus on the Apprenticeship Levy. Captured below in Table 1 is the key departments responses in terms of institutions and policies.

Table 3. Department/institution and policies

Department / Institution	Policy
HM Government The following departments are involved: Department for Education (DfE), Department for Business, Energy and Industrial Strategy (BEIS), Department for Transport (DfT), Ministry of Housing, Communities and Local Government (MHCLG)	Automotive Sector Deal: ▪ Ideas ▪ People ▪ Infrastructure ▪ Business environment ▪ Places
Department for Transport	Road to Zero
Department for Education	Career Strategy
European Union	DRIVES

Source: Authors’ own elaboration



6. Gender gap in the automotive industry

This section deals with the gender gap issue in the automotive industry, meaning that only a fraction of the engineers working in the sector are female. The gender imbalance within the workforce it is one of the key issues that continues to arise within the manufacturing sector, affecting heavily the automotive area as well. The section is divided into challenges and initiatives and addresses these imbalances as follows:

- Providing numbers that reflect the disparity among men and women in the automotive sector,
- stating that the gender gap issue starts from an early stage including the take-up of relevant subjects at school, and
- explaining that the sector's image contributes that many female engineers do not find their ways into the UK automotive industry.

6.1 Challenges

One of the key issues which continues to arise within sectors such as the automotive sector are the gender imbalances that exist within the workforce. The following section addresses these imbalances by providing numbers that reflect the disparity among men and women in the automotive sector, by stating that the gender gap issue starts from an early stage including the take-up of relevant subjects at school, and by explaining that the sector's image contributes that many female engineers do not find their ways into the UK automotive industry.

The organisation Engineering UK explained in The State of Engineering report (2018) that there is a significant gender imbalance in engineering jobs, which results into a loss of enormous potential. The gender imbalance has been a traditional issue, not only in the automotive sector, but in the overall manufacturing industry. It creates a massive problem on the supply side of the labour market, leading to a shrinking talent pool. Only 12% of the people working in engineering and technology jobs are women (47% of the UK workforce is female), which is the lowest value in Europe. The European Sector Skills Council's (2016) statistics for the year 2012 shows that it is hardly better in the manufacture of motor vehicle, trailers and semi-trailers, since only 13,7% of all people working in this field in the UK are women. This is a significant difference compared to the EU average, where 24% of the motor vehicle manufacturing workforce is female. Though, these numbers are seven years old, it can be stated with confidence that it has not changed much since then.

The disparity also becomes apparent when looking at the data on how many girls choose STEM subjects: In 2017, just 27% of entries to A levels were in STEM subjects for girls in contrast to 46% of entries for boys, and just 21.5% of students for A Level physics are female, a figure which has not varied a great deal over thirty years despite efforts to change it (Engineering UK 2018). This is especially true in computing and physics at A level, where in 2017 girls made up only 9.8% and 21.5% of these respective entries (Engineering UK 2018). This gender divide is especially acute amongst apprenticeships, with far more women taking up apprenticeships in areas such as hairdressing than in engineering, for example (Engineering UK 2018). There is also a problem of gender stereotyping when it comes to careers, including amongst teachers and parents (Engineering UK 2018; Institute of Physics 2015). One issue is that whilst girls seem to be interested up to the ages of 11 to 12 in STEM subjects and careers this interest has fallen by 15 to 16 (Engineering UK 2018; Microsoft 2017). This is also manifested in the low number of first-degree undergraduates who were studying engineering and technology, considering that only 16% of these students were female despite there being more female than male students in higher education in the UK (Engineering UK 2018). This unequal distribution of genders leads to the problem that many talents do not find their way into engineering areas, let alone the automotive industry. Engineering UK (2018) reports that ending work-related gender gaps has the potential to add £150 billion to the annual GDP of the country in 2025.

The disparity is also reflected in the gender pay gap. The UK, however, lags badly behind other countries in terms of gender pay, ranking 42nd of 118 countries with regards to gender earnings according to the Global Talent Competitiveness Index (2017). According to the SMMT (2019b: 21), in 2018, the...

"...gender pay gap in UK automotive manufacturing (including SMEs) is close to that in manufacturing overall [20.3%], with men paid 22.8% more than women".[20]

In 2017, based on median hourly earnings, men were paid 18.4% more in the UK workforce and 20.8% more than women in the manufacturing workforce, according to the Office of National Statistics (SMMT 2018a). This gender pay gap is similar to the national average in the UK automotive manufacturing sector but is better than the overall manufacturing sector. In the discipline of mechanical engineering, however, women earned 6.1% more than men (SMMT 2018a) The first gender pay gap report was published in 2018 showing quite how poorly engineering compared with the national average when it came to gender diversity and progression of women, especially when considering that – in 2016 – some 56% of the higher education population is female (Royal Academy of Engineering 2019). Women are likewise underrepresented on computer related subjects in higher education (Ecorys UK 2016). The female underrepresentation is also visible in IT apprenticeships. A report of the House of Commons Business, Innovation and Skills Committee from 2013 pointed out that some 10,000 boys had enrolled in IT apprenticeships in the previous year in contrast to just 1200 girls, and that almost 13,000 boys had registered in engineering whilst just 400 girls had done so (House of Commons Business, Innovation and Skills Committee 2013). This example outlines the challenge of bringing more women into industries such as the automotive and engineering sectors.

[20] In 2018 in the UK, meanwhile, based on median hourly earnings, men were paid 17.9% in the UK workforce and 20.3% in the manufacturing workforce more than women, according to the Office of National Statistics (SMMT 2019b).

IT Skills are also increasingly important in schools, and it is therefore of importance for teachers to have the required knowledge of these skills and this also reflects on issues of gender diversity. Initiatives includes the British Chambers of Commerce Business collaborating with the Government Equalities Office so as to link teachers with businesses and thus provide them with the knowledge and the motivation to encourage more female students to study STEM subjects (Ecorys UK 2016). Women made up just 19% of those gaining qualifications in computer science in 2009/10 in contrast to the 22% in 2005/06 (UKCES 2012). In the digital sub-sector, there were 26% of female workers in 2010, contrasting with 33% a decade earlier (UKCES 2012).

However, there is a slightly positive development when looking at the proportion of women undertaking first degree courses at an undergraduate level in engineering and technology subjects: An increase from 15.1% in the academic year beginning in 2014 to 16% in the following year (Engineering UK 2018). This was, nonetheless, as a subject area the second lowest proportion of female first degree entrants in 2015, with computer science the lowest proportion at just 14.9% (Engineering UK 2018). There were more boys than girls in every STEM subject, with the exception of biology and chemistry, and whilst over five years there was an increase in the total number of entries in computing by 117.9%, the increase in the number of girls was only 2% (Engineering UK 2018). Further, whilst there is an overall increase in the number of students taking STEM subjects, there are concerns that the pass rate is below the national average, with the exception of mathematics and further mathematics (Engineering UK 2018). Inequalities amongst students likewise has effects on staff inequalities, with only 14% of female academics in electrical, electronic, and computer engineering, and 27% in chemical engineering (Engineering UK 2018; ECU 20141; 2014b; ECU 2015a; 2015b).

Figure 9. Case study on gender gap in engineering

Case study: Kerrine Bryan, electrical engineer, on gender gap in engineering:

A woman who has set herself the task of minimising the gender imbalance is the electrical engineer Kerrine Bryan. She wrote the book 'My Mummy is an Engineer' and was cited in the Guardian with the following words:

"We're losing potential engineers at every stage of life, and it starts from a young age because bias and misconceptions in media and toys often implant ideas into children's minds that engineering is for men and involves getting your hands dirty and fixing things, which doesn't appeal to girls if they're brought up to believe they should be quiet, neat and tidy."

"There's so much embedded in our culture saying engineering isn't for girls, and people still think of engineers as the men who fix your washing machine, not the people at the forefront of designing creative solutions to the world's problems."

Kerrine Bryan's statements presented in Figure 9 suggest it needs a cultural change. Some years ago, a The Times article (Bennett 2013) cited the MP Adrian Bailey [21]:

"At the heart of the matter [under-representation of women in some sectors] is the need for cultural change. Without this, we address symptoms rather than causes."

One solution should be to integrate career advice into school education at an early stage to encourage girls to pursue STEM careers, as well as to reduce prejudices about technical jobs. One approach for companies to become more attractive for female workers might be...

"...reviewing their family friendly policies and flexibility around shift patterns"
(Automotive Council UK 2016b: 19),

...thereby offering a better work-life balance. It will be crucial for the success of the automotive industry that relevant actors such as career advisors, industry skills providers, policy makers and associations tackle the gender imbalance issue effectively and – considering that the nature of automotive work has changed and much of the dirty work is now done by machines – communicate these industrial changes and contribute to a cultural change. The next section will provide information on initiatives that may be part of a chance and could make a contribution that more women want to work in engineering and the automotive sector.

6.2 Initiatives

There have been a number of efforts and initiatives to promote equal rights between men and women in the UK industry. For example, the Equality Act 2010 – that came into force in April 2017 – means that organisations over 250 employees are required to publish the data relating to their gender pay gap, the details regarding the proportion of male and female employees in different bands of pay, their gender bonus gap, and a breakdown of how many women and how many men get a bonus (Engineering UK 2018). It is therefore required, as of the 5th April 2018, that all employers that have 250 or more employees employed by legal entities in the UK must report their organisation's gender pay and bonus gaps (SMMT 2018a).

An example of work being undertaken to improve the gender balance and pay gap issue includes the UK Automotive 30% Club[22]. This is a voluntary group of managing directors who come from automotive manufacturing, retailing, and supplier companies. Through their "30 by 30" strategy, it follows the...

"...purpose of achieving a better gender balance within the automotive industry, and with the aim of filling at least 30% of key leadership positions in the member organisations with women by 2030"
(UK Automotive 30% Club 2019).

[21] Bailey is a Labour MP and was the chairman of the Business, Innovation and Skills Committee from 2010-2015.

[22] The UK Automotive 30% Club was founded by Julia Buir, the CEO of Gaia Innovation Ltd.

The Club's members include Bentley, Ford, Kia, Toyota, Mazda, Renault, and VW Group, and it also works with charities and supporters including Speakers for Schools, the Inspiring Women campaign, McKinsey, the Institute of the Motor Industry, and Loughborough University School of Business and Economics (SMMT 2018a).

Another initiative includes the STEM Teaching Programme and the Engineering Leadership Scholarship. The STEM Teaching Programme provides opportunities for teachers in STEM subjects to share good practice, and the programme is achieving gender diversity, with a split of 54% to 46% male to female amongst the teachers (Royal Academy of Engineering 2017). As for the Engineering Leadership Scholarship, 73% of respondents conducted amongst alumni of the programme reported that they had entered employment immediately following graduation in engineering businesses (Royal Academy of Engineering 2017). Of the programme, in 2016 men made up 66% of the programme and women made up 34% of the programme, which is higher than the gender diversity in the engineering profession overall, although still leaves room for improvement (Royal Academy of Engineering 2017). One problem is the industry's image. Even at a young age this exists, with the Engineers and Engineering Brand Monitor 2015 showing that of aged 7 to 11-year olds, 52% of males had a positive impression of engineering whilst only 29% of females had a positive impression of engineering (Royal Academy of Engineering 2017).

There are also efforts by the Trade Union Congress to tackle gender imbalances in the industry, working on helping union representatives in the workplace improve female recruitment into high-quality apprenticeships (Strategic Transport Apprenticeship Taskforce 2019). The UK Government has committed to the promise that by 2020 there will be three million apprenticeship starts (HM Government 2015), as outlined in further details below. Further, the Government has set a target of 2.3% of staff who are doing an apprenticeship for public sector organisations (Unionlearn 2018). Trade unions fear that this target of three million apprenticeship starts will mean that quality will lose out to quantity (Unionlearn 2018). This is based on a concern that employers may in some instances try and recoup their levy funds (refer to 7.4 Government response on challenge for details on the introduced Apprenticeship Levy) through the prioritisation of the quantity of starts over their quality (Unionlearn 2018).

Initiatives include the Apprenticeship Diversity Champions Network (ADCN) which aims to champion diversity (refer to Figure 10 for an interviewee's statement on diversity) in apprenticeships amongst employers and encourage people who are under-represented such as women to take apprenticeships into consideration, and includes members such as B&Q, Rolls-Royce, and some local authorities; the Strategic Transport Apprenticeship Taskforce (STAT) which represents trade unions and aims for an increased number of women amongst engineering and technical apprentices; the employer toolkit of the Learning and Work Institute which has case studies of employers who utilise inclusive apprenticeships together with advice surrounding this; the Women in Science and Engineering campaign, which seeks to redress the gender imbalance in the sector; and the Civil Service National Trade Union Committee agreement, which is an agreement between the Civil Service in England and seven trade unions regarding equal rights in relation to recruitment, pay, and training and support (Unionlearn 2018). Refer to Table 4 for an overview on the previously mentioned diversity initiatives.

Figure 10. Automotive expert on diversity

HORIBA MIRA expert (interview #1) on diversity:

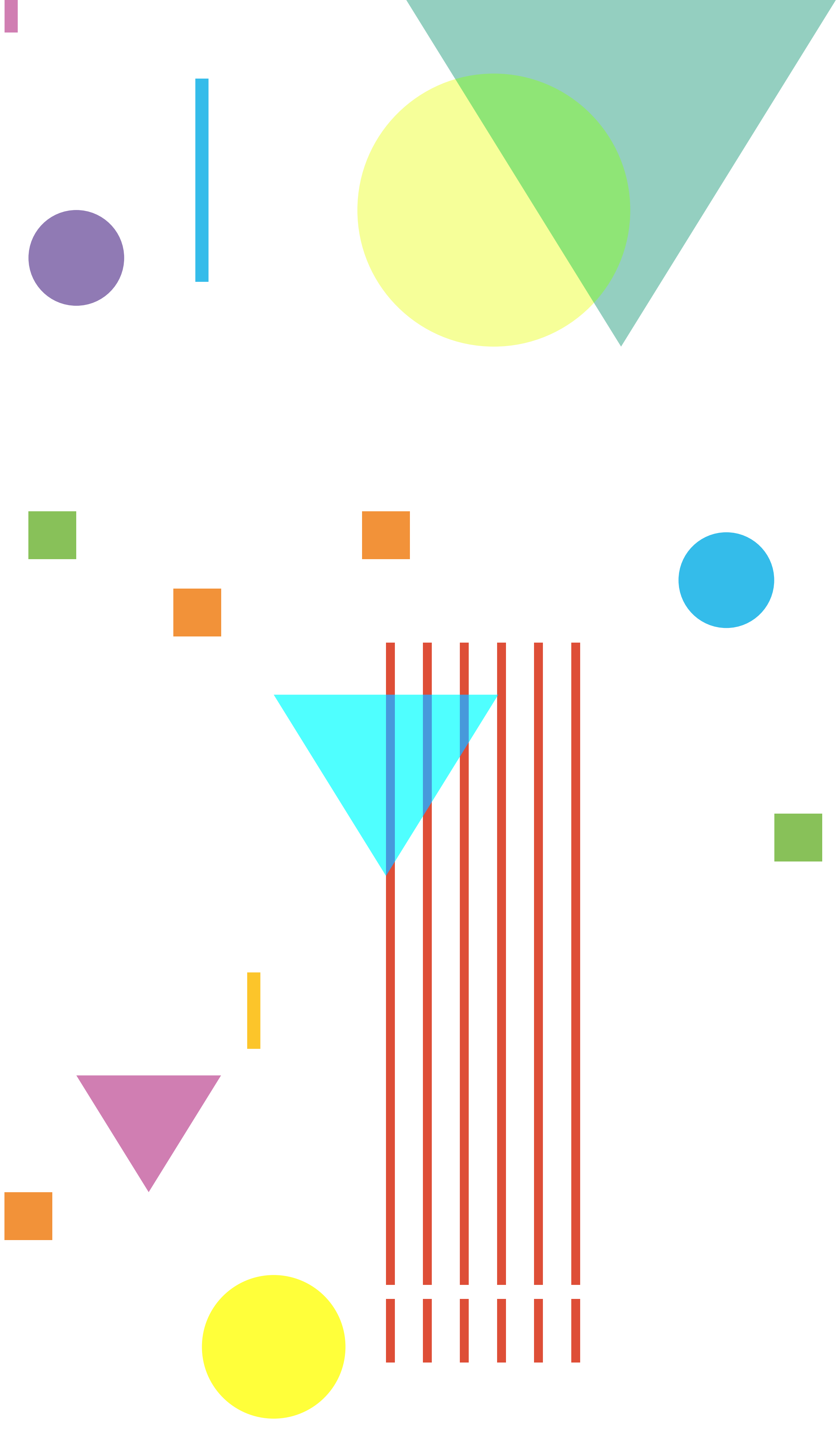
"At the moment I know that there are some initiatives for university level and above, but I think the gender imbalance begins well before that, which means we need to look at ways of attracting all sorts of skills. That's not only women, but also the ones who don't think they have anything to give to the automotive industry. People like policy makers, designers, lawyers, games techs, lots and lots of different skills…to show them that their skills can be applied laterally, not only in the direct way they are trained for, but also in terms of the automotive application."

The Trade Union Congress has also recognised the importance of digital skills in the workplace, and is therefore undertaking efforts to assist workers in acquiring the required skills, as well as advising union representatives and employers as to how they might assist and train their employees (Unionlearn 2019). This includes through case studies of companies that have successfully worked to improve digital skills, and providing links to courses and guides which may help employees.

Table 4 - Overview on diversity initiatives

Initiative	Explanation
Apprenticeship Diversity Champions Network (ADCN)	Aims to champion diversity in apprenticeships amongst employers, encourage people who are under-represented
Strategic Transport Apprenticeship Taskforce (STAT)	Represents trade unions and aims for an increased number of women amongst engineering and technical apprentices
The employer toolkit of the Learning and Work Institute	Case studies of employers who utilise inclusive apprenticeships together with advice surrounding this
Women in Science and Engineering campaign	Seeks to redress the gender imbalance in the sector
Engineering	Agreement between the Civil Service in England and seven trade unions

Source: Authors' own elaboration



7. Apprenticeships

This section focuses on apprenticeships. It states what the origins of apprenticeships in the UK are, deals then with the modern apprenticeship schemes, followed by a sub-section on apprenticeships in the automotive industry by providing data on the number of apprenticeships starts in the last years, as well as programmes that serve to keep as many apprentices in the automotive industry as possible. This section closes with the sub-section Government response that summarises government policies on apprenticeships with a focus on the so-called Apprenticeships Levy.

7.1 Origins of apprenticeships in the UK

Apprenticeships in the UK have a long history dating back many centuries to medieval craft guilds in the Middle Ages, when members of the upper class would send their offspring to trusted guardians for training purposes. Though the numbers were small it became a respected form of training that would endure. By the turn of the Nineteenth Century There were an estimated 340,000 apprentices undergoing training annually and by the 1960s a third of male school leavers were engaged as apprentices (House of Commons (HoC) 2015). These boys entered apprenticeships at around the age of sixteen served for a period of between three and five years learning their trade usually by working alongside a journeyman and perhaps taking a part-time course in either a local Technical or Further Education College. The longest time served was for apprentice toolmakers in the Coventry engineering industry whose training period could last as long as seven years (Richardson and Harris 1972).
During such apprenticeships the traditional emphasis was on time-served, but by the 1960s the efficiency and effectiveness of the process was beginning to be queried by both government and employers. In 1968 the Royal Commission on Trade Unions and Employers' Associations was scathing on the quality of training available through such traditional routes. The Commission, established to examine work relations and make recommendations around developing a modern workforce, noted that:

**"Training... is an area in which restrictive traditions have especially deep roots in British industry and where the presence of technological change makes the need for a radical change in outlook particularly urgent."
(Royal Commission on Trade Unions and Employers Associations 1968: 693)**

The Commission went on to recommend that government departments such as the Department of Employment and Productivity challenge outmoded methods and seek to replace them. The culture began to change and more emphasis was placed on outcomes as key concerns such as competences, national standards, changing work processes, the increasing pace of technological change and even the paucity of women in engineering industries and related trades came to the fore as women increasingly entered the workforce (Evans 2011). Apprenticeships entered a slow decline, with half as many in the mid 1990s as there was at the end of the 1970s (HoC 2015). Gospel estimates there were just 53,000 in the engineering sector by 1990 (Gospel 1995). Changing work practises, a diffusion of labour-saving technology and challenges to major employers such as the automotive sector were discouraging uptake (Begley and Donnelly 2015). Additionally, the expense and the length of time taken to train apprentices were also forcing firms to rethink increasingly about control of and recovery of costs.
One answer was to look at how craft based tasks could be disaggregated and divided between teams of workers whose members could be trained to carry out several tasks competently thereby reducing the need for so many fully trained apprentices, thus creating a flexible work force to reinforce attempts at cost recovery (Ackroyd and Stephen 1998; Mair 1994). Moreover and perhaps more importantly, 'flexible workers' did not require to be paid at a fully trained craftsman's rate of pay. Such moves have also been seen as attempts by management to gain greater control over the shop floor, especially in highly unionised factories in the Midlands (British Leyland and Chrysler) but less so in Luton (Vauxhall) and Dagenham (Ford) where union power was traditionally weaker. These moves were also designed to exert greater control over the trades unions by reducing the role of the traditional shop stewards and replacing them with team leaders and workers' representatives. (Begley and Donnelly 2015).

The early 1960s witnessed attempts to remedy the weaknesses, particularly those in technical education, in the apprenticeship system (Evans 2011). Probably the most important of these was the establishment of Industrial Training Boards (ITBs) across a large number of sectors. These were financed by a financial levy on the participating companies, but there was no compulsion for firms to become involved with training programmes. In the following decade in 1972 the Employment and Training Act established the Manpower Services Commission (MSC). It was not until the early 1980s that the latter rose to prominence when, with the abolition of most of the ITBs and amid rising youth unemployment, the Thatcher administration charged the Secretary of State for Employment, Sir David Young, with the task of devising courses to address youth unemployment and at the same time provide young people (sixteen to eighteen year old) with skills to enable their transition into work under what became known as the Youth Training Scheme (YTS), involving both public and private providers.

Other initiatives such as the Technical and Vocational Education Initiative (TVEI) followed (Unwin 2010). These programmes, however, had little impact due to the low levels of education and skills imparted and so the MSC was abolished in 1987 and replaced by Technical and Enterprise Councils (TECs). Clearly, despite the plethora of initiatives, little success was achieved. The reasons for this may lie in the fact that there were simply too many such initiatives with little coherence and coordination between them in such a short space of time.

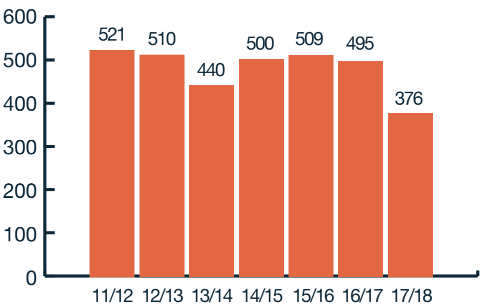
In essence the education and training policy initiatives of the 1980s did little to enhance the low esteem accorded to technical and vocational education, and may well have been more to do with social engineering to massage the youth unemployment figures than to address the lack of manufacturing skills in a coordinated manner (Evans 2011; Pemberton 2001).

In response to these shortcomings new initiatives were rolled after 1993, eventually becoming known as Modern Apprenticeships (MA). Apprentices would count as contractually paid employees and be paid a wage, with an emphasis on skills acquired over time served. Apprentices were required to work towards an NVQ level 3 qualification. National Traineeships were also established as a route through into MAs. Within 5 years numbers enrolled in MAs had reached a quarter of a million in England and Wales (HoC 2015).

Initially the training was not of the highest standard (Ryan and Unwin 2001). In response the MA scheme has undergone a number of revisions; in 2000, when minimum standards were clearly defined, again in 2004, when they became Advanced Modern Apprenticeships, and the upper age limit was removed to improve accessibility. In 2010 Higher Apprenticeships (equivalent to foundation degrees or above) were brought in and the Young Apprenticeship scheme scrapped. The new Higher Apprenticeships were accompanied by business incentives to improve numbers and MAs were also extended to older workers in the same year. In 2012 minimum standards were raised once more and new funding systems introduced. Other complementary initiatives include the establishment of University Technical Colleges to encourage school goers to specialise in engineering and the sciences while at secondary school (Begley and Donnelly 2015; HoC 2015).

Since the most recent reforms of note, the numbers of apprentices in England alone are significant. In 2017/18, there were 814,800 training as apprentices in England (HoC 2019). Despite these impressive figures, the most recent trend in terms of starts had been one of decline, as shown in Figure 11 below.

Figure 11. Apprenticeships starts in England since 2011/12



Source: HoC (2019)

It may be that as national and regional economies come under increasing pressure from new work modes and newly competitive trade partners that upskilling and improving the apprenticeship scheme in the UK is once more required.

7.2 The modern apprenticeship schemes

There have been a number of significant changes with regards to technical and vocational education since the Perkins Review of 2013. These include the Apprenticeship Levy, new standards for apprenticeships, the introduction of T levels in the Post-16 skills plan, a target that by 2020 there will be three million apprenticeship starts, and the establishment of the Institute for Apprenticeships and Technical Education (IfATE) (Royal Academy of Engineering 2019) [23]. The new Skills Plan committed to creating fifteen new routes for technical education (Burden 2017). Apprenticeships were moved from apprenticeship frameworks to standards which created by groups of employers in new reforms with the intention that these will respond better to the needs of the industry (Royal Academy of Engineering 2019). These provoked concerns amongst the engineering community that the apprenticeship becomes the qualification rather than having a separate qualification attached to it, and that rather than having continuous assessment throughout the apprenticeship there is now rather assessment at the end of the apprenticeship (Royal Academy of Engineering 2019). The Civil Service in England aims that by 2020 that will be 30,000 apprenticeship starts (Unionlearn 2018).

There were, in 2017/18, some 814,800 people who were participating in an apprenticeship in England, but there were 94,000 less people participating in an apprenticeship in 2017/18 than in 2016/17 (Powell 2019). In 2017/18 there were 375,800 apprenticeship starts and 276,200 apprenticeship achievements, but after the introduction of a new funding system for apprenticeships there were 119,100 less starts in 2017/18 than in 2016/17 with this affecting those at the intermediate level for apprentices aged 25 and over especially (Powell 2019).

In addition to apprenticeships, there are also the introduction of T levels. T levels are post-16 qualifications which are set to start from September 2020 and will be equivalent to three A levels (Department for Education 2019b). This is outlined in the T Level Action Plan 2018. These were proposed by the independent review of technical education as a technical alternative to A levels and also providing a simplification of the landscape of vocational qualifications (The Royal Academy of Engineering 2019). These new qualifications are being backed by approximately £500 million a year which has been announced (Department for Education 2019b). The independent review of technical education was chaired by Lord Salisbury, and then accepted in the Post-16 Skills plan by the Department for Education (The Royal Academy of Engineering 2019). Rather than the circa 13,000 publicly funded qualifications, there will rather be 25 T levels (The

[23] The IfATE is an employer led crown Non-Departmental Public Body which oversees apprenticeship standards and assessment plans, and technical and apprenticeship qualifications.

Royal Academy of Engineering 2019). These will be based on 15 broad occupational clusters or routes (The Royal Academy of Engineering 2019). These include routes such as manufacturing, construction, and digital (The Royal Academy of Engineering 2019). The qualifications include a two-year principally classroom-based programme, a 45-day industry placement, and also minimum requirements in English, mathematics, and digital (The Royal Academy of Engineering 2019). This industry placement will be at least 315 hours (Department for Education 2019b; Education and Skills Funding Agency 2019c). The expectation is that a T level will take approximately 1800 hours over the two years, including the placement, as opposed to apprenticeships where it is normally approximately 80% on the job (Department for Education 2019b). There are also panels are made up of experts and professionals from across business for the enacting of these qualifications, and providers who are offering the first courses (Department for Education 2018c). The Royal Academy of Engineering (2019) welcomed the announcement that T Levels will receive UCAS points.

Already in 2007, the Department for Innovation, Universities and Skills (DIUS) (now a part of the Department for Business, Innovation and Skills) stated that "the Government has committed itself to the ambition of becoming a world leader in skills by 2020" (HM Government 2007: 9). However, 12 years later, the problem that apprenticeships that cover important skills in relevant sectors are not filled is as acute as ever. With 59,000, the number of apprenticeship-starts in the engineering and manufacturing technologies sectors in academic year 2017/2018 (65,000 in 2016/2017) is the lowest since 2011/2012 in England (55,000) (Powell 2019: 14). This number (59,000) corresponds to 16% of all apprenticeships started in 2017/2018 (375,800). This reduction may be linked to the perception of school-leavers that less and less skills are required for the manufacture of cars considering the increasing robotization/automation and digitalisation.

However, it also reflects a general trend that apprenticeships do not seem to be highly popular among teenagers, which has partly to do with the lack of knowledge that apprenticeships may be ideal to learn relevant skills theoretically while applying these in the respective company. Another factor is the perception of many young people that anything, but studying is not a good basis for a successful career. The provision of skills and apprenticeships is devolved in Scotland, Wales, and Northern Ireland, and in these three nations provision has been aligned with existing recognised qualifications and new provisions are developed according to the needs of the labour market (Royal Academy of Engineering 2019). This is in contrast to the approach in England, where standards are approved by employer groups (Royal Academy of Engineering 2019). The Scottish youth employment strategy, 'Developing the Young Workforce' (DYW), has included initiatives such as introducing Foundation Apprenticeships and Modern Apprenticeships, and the range of subjects covered by foundation apprenticeships is driven by the nature of growth industries and the shortages of skills, with uptake exceeding the targets of the Scottish government (Royal Academy of Engineering 2019). Pre-Apprenticeship Programmes have been developed by the Welsh Government, beginning with Junior Apprenticeships which are open to 14 to 16 year olds (Royal Academy of Engineering 2019). These allow pupils studying GCSEs in English and Maths the opportunity to be introduced to work-based learning (Royal Academy of Engineering 2019). Annual reports which are produced by the Regional Skills Partnerships (RSP) drive the creation of skills provision for those aged post-16, and as such the creation of new apprenticeships are linked to the demands in regional skills (Royal Academy of Engineering 2019).

These new apprenticeship standards, and the inclusion of digital skills within the T Level qualifications, has been welcomed by organisations such as Jisc (2018a) who view skills in areas such as digital entrepreneurism, digital creation and innovation to be vital to the workforce of the Industry 4.0. Digital technology might be used in education, for example, through short videos, podcasts, and readings in the time of the student, to the allow face to face time for collaborative activities in small groups or for discussion (Jisc 2018a). Likewise, lifelong learning skills are going to be of increasing importance, and rather than obtaining one single qualification over a single period of time, short courses for upskilling may prove important (Jisc 2018a). Jisc (2018a) view the three principle developments currently driving change in education as being the internet of things, machine intelligence, and big data.

7.3 Apprenticeships and the automotive sector

Further to the above section on apprenticeships, apprenticeships are likewise important in the automotive sector specifically. Apprenticeships are one of the building blocks of the future success of the UK automotive industry. The following numbers illustrate that there is a positive development: More than 1,000 young people started their apprenticeship in 2018, which is an increase of more than 40% compared to the 700 apprentices in 2017 (SMMT 2018a; 2019b). Moreover, "1,600 apprentices recruited in previous years were retained by signatories, up 47% on the year before [950 apprentices]" (SMMT 2019b: 20).

It is the responsibility of industry associations, manufacturers, and policy makers to make sure that apprenticeships gain more popularity and that the automotive sector attracts talented people. The Automotive Sector has led reforms of apprenticeships including through developing and piloting the new 'trailblazer' standards, and through the setup of the Apprenticeship Matching Service (HM Government 2018). The Automotive Apprenticeship Matching Service might be one of the approaches to make sure that interested young people obtain an apprenticeship place, even if it is not the case with one of the few OEMs. The Automotive Apprenticeship Matching Service was introduced by the Automotive Industrial Partnership, which will offer candidates from the OEMs or other large businesses in the automotive sector for the industry as a whole, so as to retain new entrants who are qualified for the apprenticeship training programme but cannot join because there are not sufficient places (Automotive Council UK 2016b). The Matching Service can be a considered a tool to make sure that talents are kept in the industry. It partners with companies such as BMW, JLR, Nissan, and Toyota and aims to “redirect high quality talent from over-subscribed automotive apprenticeship programmes to other companies within the sector that have opportunities” (SMMT 2019e).

Supply chain respondents seem positive towards the Matching Service, given they may not have the time or resources to test recruitment themselves, this would mean that customers had already assessed the quality of candidates (Automotive Council UK 2016b). Further suggestions include an industry-wide apprenticeship scheme so as to encourage employers from across the sector to take up more apprenticeships, ensure high standards throughout the sector, provide more depth and breadth of learning, and aid retention (Automotive Council UK 2016b).

However, apprenticeships may be a crucial way of filling the existing skills gaps that are prevalent in the development of innovations. From the perspective of special car manufacturers, apprenticeships play an important role in the provision of skilled labour, however due to the high costs involved, there is the understanding that the skills gaps may only be filled when the government and key stakeholders agree on a common agenda (SMMT 2017) [24]. The AIP might play a key role in the endeavour to address the skills shortages (see Figure 12 for more information on the AIP’s role.

Figure 12. The role of the Automotive Industrial Partnerships for Skills (AIP)

The role of the Automotive Industrial Partnership for Skills (AIP):
▪ has been set up in 2015 by the Automotive Council with initial grant support from the UK Government (HM Government 2018) ▪ This partnership develops a skills roadmap for the sector to address the arising skills shortages **Intention:** Addressing the long-term skills gap in the automotive OEM and wider engineering sector in the UK (Automotive Council UK 2018) **Aim:** Bringing in the next generation of engineers and technicians into the Automotive Sector and boosting of apprenticeships (HM Government 2018) **How it works:** Organisations such as Jaguar Land Rover, Nissan, Mercedes, Bentley, and BMW provide details to a central database of high-quality candidates, and a matching team is then provided for the individuals and engineering businesses (Automotive Council UK 2018). ▪ With minimal investment, supply chain businesses in the automotive sector can access a broader and deeper talent pool (Automotive Council UK 2018).

There is also the Automotive Trailblazer Group that was initially formed through the Automotive Industrial Partnership in 2014, with the initial employers being Jaguar Land Rover, BMW, Toyota, Nissan, Vauxhall, and Ford, and sought to improve the standard of apprenticeships (Automotive Council UK 2018). As stated in Section 4.4 Digital Automotive skills requirements the Automotive Trailblazer Group intends to set standards and improve the quality of apprenticeships. Toyota, one of the involved companies, stated the importance of apprenticeship programmes, of which not only the car producer benefits, however suppliers with which Toyota cooperates. The company knows well that not all apprentices will end up working for the company, however there is a high demand in the automotive supply chain – the quality of which is important for Toyota’s success.

7.4 Apprenticeships and the automotive sector

In 2015, the Government announced that it would create a new tax for large employers, the so called Apprenticeship Levy, “to fund its flagship ‘3 million new apprenticeships’ policy” (House of Commons Library 2015: 21). In April 2017, the Apprenticeship Levy came into force and has to be paid at 0.5% of an employer’s annual pay bill if it is over £3 million each year. Employers can recoup this payment by using it for the funding of training for apprentices and these apprenticeship levy funds can only be spent on training which contributes to apprenticeship frameworks or standards (Unionlearn 2018; Royal Academy of Engineering 2019). The Government explained in its Spending Review and Autumn Statement (Keep, Delebarre, Keen, Rhodes, and Wilson 2015: 21):

“The levy will be used to fund 3 million apprenticeships by the end of this Parliament. All employers, regardless of whether they pay the levy or not, will be able to access government funding for apprenticeships. Those who pay the levy will receive more in funding than they contribute through top-ups to their levy accounts worth more than their own contributions.”

The underlying assumption is that not all employers use the opportunity to train apprenticeships or use the available funds. Further, employer-led development of new occupational standards has been enabled (Unionlearn 2018) and, when candidates undertaking Higher Apprenticeship, Advanced Apprenticeship, and Intermediate Apprenticeship are not successful with one employer, they could be passed to the wider engineering industry (Royal Academy of Engineering 2019). Larger employers were, from April 2019, able to transfer up to 25% of their levy funds to businesses in their supply chains whilst those companies which are exempt from the levy with smaller wages bills will see a reduction in their required contribution to training costs for new apprentices (Royal Academy of Engineering 2019).

There are concerns surrounding underspend regarding the levy money which is reclaimed with the Open University (2018) suggesting that only 8% of the approximately £1.8 billion paid

[24] https://www.smmt.co.uk/wp-content/uploads/sites/2/SMMT-Specialist-Car-Manufacturers-Report-2017.pdf .

by business in the first year into the levy has been spent (Royal Academy of Engineering 2019). Some 61% of business leaders, however, viewed the apprenticeship levy as helpful in reducing the skills shortage over the coming five years (The Edge Foundation 2018).

There are also degree level qualifications being rolled out. The UK Government extended the new apprenticeship standards in 2015 and created higher-level apprenticeships at bachelor and master's level (Royal Academy of Engineering 2019). Approximately 2.5% of higher apprenticeships were in engineering and manufacturing technologies in the period of 2016/17 amounting to approximately 900 apprentices (Royal Academy of Engineering 2019). In addition, Graduate Apprenticeships are being rolled out in Scotland, and in 2018 these involved twelve universities and colleges (Royal Academy of Engineering 2019). Further, in October 2018 apprenticeships at a degree level were introduced in Wales, with the apprenticeship advisory board chaired by the head of CBI Wales and including membership from businesses, and digital/ICT was the first framework which was covered (Royal Academy of Engineering 2019).

In 2017, the former Minister for Apprenticeships and Skills Anne Milton appointed several MPs "to champion the apprenticeship programme" that refers to the Apprenticeship Ambassador Network (AAN), which is "a group of employers whose main aim is to spearhead the drive to engage new employers to commit to apprenticeship delivery" (GOV.UK 2019b). Their role is to promote apprenticeships in the interaction with a variety of stakeholders such as schools, trade associations, employment bodies and policy makers. Another programme is the Apprenticeship Diversity Champions Network (ADCN) that "encourages more people from underrepresented groups, including those with disabilities, women and members of the black, Asian and minority ethnic (BAME) communities, to consider apprenticeships". The ADCN network consists of representatives from various societal groups such as universities, corporations and city councils.

8. Future opportunities and challenges

This section discusses the opportunities and risks of new technologies, introduces so called 'innovation assets' and states how multi-stakeholder initiatives may have a positive impact on the provision of relevant automotive skills. Sub-section 8.2 will provide an overview on the implications of Brexit by stating various perspectives on the consequences of the United Kingdom's exit of the European Union. Finally, this chapter concludes with recommendations on how the different stakeholders may approach the skills shortages in the automotive industry.

8.1 Opportunities (and risks) due to new technologies

The future opportunities for the British automotive industry lie particularly in the automotive transformation and digital skills are of great importance for UK manufacturers and suppliers to successfully shape this change and contribute to the increasing digitisation and electrification in the automotive sector.

The UK automotive industry has the chance to use the momentum and take the leadership in the development of future technologies by becoming a hub for automotive competence. Public-private research organisations such as the WMG centre High Value Manufacturing Catapult, the National Automotive Innovation Centre (both based at Warwick University), or the Institute for Advanced Manufacturing and Engineering (AME) (which is a collaboration between Coventry University and Unipart Manufacturing Group) form centres that are able to develop innovative ideas and combine academic excellence with practical, industrial expertise. Bailey and Amison (2014: 9) called these type of facilities “an impressive collection of automotive and engineering-related expertise, or ‘innovation assets’ as they are described locally“. Refer to Table 5 for a list of ‘innovation assets’ in the West-Midlands region. These competence centres do not only create highly skilled jobs themselves; they also contribute to the automotive industry by providing relevant research and consulting expertise (see Table 3 for a list of these facilities in the West-Midlands). For example the National Automotive Innovation Centre (NAIC) at Warwick University is expected to employ 1,000 people with the objective to “develop novel technologies to reduce dependency on fossil fuels and to reduce CO2 emissions” (The University of Warwick 2019a).

Table 5. The West-Midlands as an example for a region with many ‘innovation assets‘

Facility name	Partner/Type of Facility	Location	Year of Foundation
Warwick Manufacturing Group (WMG)	▪ Research and knowledge transfer in engineering, manufacturing and technology ▪ One of seven research centres of the High Value Manufacturing Catapult	Warwick University, Coventry	1980
National Automotive Innovation Centre (NAIC)	Joint and Venture of Warwick Manufacturing Group (WMG, founded 1980), Jaguar Land Rover and Tata Motors, also supported by the UK Government's Higher Education Funding Council for England	Warwick University, Coventry	2018
Institute for Advanced Manufacturing and Engineering (AME)	Collaboration of Coventry University and Unipart Manufacturing Group	Coventry	2014
Manufacturing Technology Centre (MTC)	Independent Research & Technology Organisation (RTO)	Coventry	2010
Advanced Propulsion Centre (APL)	A joint venture between UK Government and the automotive industry	Warwick University, Coventry	2014
MIRA Technology Institute (MTI)	MTI is a partnership led by North Warwickshire and South Leicestershire College, along with HORIBA MIRA, Coventry University, Loughborough University and the University of Leicester.	Nuneaton	2012

Source: Authors' own elaboration)

Announced investments from JLR in electrification by, for example, revealing plans about building electric cars at the Castle Bromwich plant are required to keep and develop a highly skilled and future-oriented workforce. JLR's call for 'gigafactories' [25] is backed by the Faraday Institution's (2019: 1) forecast that "in the absence of any gigafactories producing batteries and associated EV manufacturing, […] 114,000 direct automotive jobs would be lost by 2040." This slightly pessimistic statement is based on the assumption that "domestic vehicle producers would gradually wind down their production of internal combustion engine vehicles" (Faraday Institution 2019: 1) and many of the currently 186,000 employed people would lose their job. However, "job creation will outpace job losses in the UK only if the UK secures both EV and battery manufacturing" (Faraday Institution 2019: 3) (refer to footnote 26 for information on the Government's plan to invest in a battery factory).

In contrast to this is SMMT report (SMMT 2019f: 16), which indicated that the potential overall impact of CAVs on the British economy will be massive: The authors estimated an economic growth of £62 billion and 55% new highly skilled automotive jobs by 2030. The report also stated that the UK would benefit economically and socially of a CAV adoption, which may create 420,000 more jobs. Refer to Table 13 for a positive and negative outlook on the effects of the automotive transformation on the UK automotive industry.

In times of an aging population and increasing retirement age, the process of digitalisation and automation may be a chance to stem the reduction of the workforce (SMMT 2019b). An aging workforce may not be able anymore to work manually, however their skills could be used in the "digital process control" (SMMT 2019b: 33). Some of these people might need upskilling to adapt to the new requirements

Figure 13. Positive and negative outlook of automotive transformation

The positive outlook:

"Digitisation of the automotive value chain is forecast to help create more than 20,000 new jobs in the automotive sector alone. Of these, 11,000 (55%) are expected to be highly skilled across both upstream and downstream services."

SMMT (2019f: 16)

The negative outlook:

"In the absence of any gigafactories producing batteries and associated EV manufacturing, we forecast that 114,000 direct automotive jobs would be lost by 2040."

The Faraday Institution (2019: 1)

8.2 Implications of Brexit

The uncertainty around Brexit poses a major challenge and a high degree of uncertainty for the automotive industry. The Automotive Council UK (2018) assumed in their report on the international competitiveness of the UK car sector that the UK Government and the EU will negotiate successfully, in other words, avoid a hard Brexit. However, the situation in August 2019 is that a "no deal" Brexit is more likely than a soft Brexit. Therefore, it is difficult to anticipate what will happen after 31 October 2019 – the new Brexit deadline – and what the implications for British businesses will be. What has already become apparent, however, is that car manufacturers are withdrawing investments (e.g. BMW) due to uncertainty and are partially cutting back production (e.g. JLR) [27] or think about moving production to other countries (e.g. the PSA Group announced to close Vauxhall's production plant in Ellesmere Port if it becomes unprofitable after Brexit) [28]. One of UK's largest trade unions, Unite the Union (with more than 1,2m members), mentioned another problem, which the union's assistant general secretary for manufacturing Steve Turner stated the following way: "There is a £330 million hole in investment into the UK auto sector because money must now be diverted into no deal preparations, draining the life out of the industry. That is money that ought to be creating new jobs and investing in new models and a future dedicated to the UK." That is also be money that is missing for (digital) skills training.

The impact that the Brexit will bring can also be seen in the strong trade relations between the UK and the EU. The following numbers prove the deep integration of UK's automotive industry with the EU: In 2018, 68,4% of the cars that were registered in the UK were imported from the EU and more than half (52,6%) of the cars that were assembled in the UK were exported to countries within the EU. The importance of and the dependence on the European supply chain is expressed in the following statistics: 80% of all the imported components come from the EU and 69% of components built in Great Britain are exported to the EU (SMMT 2019c: 19).

Though, the UK Government stated in March 2019 that "car makers relying on EU supply chains would not face additional tariffs on car parts imported from the EU to prevent disruption to supply chains", automotive companies are worried that a no-deal scenario increases the cost and efforts of managing an already complex and interwoven supply chain. Without specifying how high the tariffs will be, the Government stated in the same article that it would retain "the number of tariffs on finished vehicles in order to support the automotive sector". In the same month, a Ford spokesman was cited in the BBC that "tariffs would deal a devastating blow to much of the complex and integrated automotive industry and would damage the competitiveness of Ford's engine manufacturing in the UK". A no-deal Brexit would add 10% of tax on the price of cars

[25] In this context, JLR refers to a gigafactory as a production plant of batteries that may supply batteries for several OEMs. It "could be the UK's answer to Tesla's gigafactory in the Nevada desert". In May 2019, BEIS announced "a new £28 million investment in the UK Battery Industrialisation Centre" ("on top of £80 million initial investment in the centre") that is located in Coventry. The Ministry calls it a "stepping stone for our ambition for a Gigafactory in the UK – a large-scale battery technology factory for electric vehicles."

exported to the EU and the UK may levy a similar tax on cars imported from the EU.

The Faraday Institution noted in their report (2019: 1) on the UK vehicle and battery potential to 2040 that Brexit determines decisively whether the "UK remains a sensible place for manufacturers to locate the production of vehicles". Also, Brexit may have serious implications for businesses using just-in-time processes considering that components worth £35m are delivered every day from the EU (SMMT 2019c). The Strategic Transport Apprenticeship Taskforce (2019) stated in their report that Brexit may lead to further employee shortages in the transport sector. In a briefing paper published by the House of Commons, the authors (Brown and Rhodes 2018) cited The Business, Energy and Industrial Strategy Committee that a 'no-deal' could cost the UK hundreds of thousands of jobs and would be highly damaging for the domestic automotive industry. However, the report also gathered optimistic views regarding the post-Brexit time. For example, it would enable British manufacturers to better seize opportunities in the Asian markets. The economics professor, Patrick Minford, was quoted as saying that Brexit leads to favourable exchange rates and increasing competition, which, in combination with UK's highly skilled automotive workforce, can lead to a more "productive future" (Brown and Rhodes 2018: 16). All in all, it needs to be said that the perspectives that see Brexit as an economically positive event for the UK tend to be in the minority.

Another important aspect concerns the collaboration of UK universities and research institutes with European institutions, which not only affects common research projects, however also the exchange of knowledge that is required for the development of crucial skills. The Automotive Council UK (2018) calls on the government to guarantee the funding that has so far been channelled from the EU into research projects in order to be able to continue collaborative international research.

8.3 Recommendations

There are a couple of recommendations that need the commitment of the different relevant actors – the triple helix consisting of academia, industry and government:

- While there are already initiatives and programmes that involve all three actors, the cooperation among policy makers, industry associations, and academic institutions could be more intensive, and strategies better aligned.
- Training initiatives and programmes need continuous input from OEMs and research centres to provide (digital) skills relevant to industry and to maximise the learning effect.
- Training programmes need to be harmonised and promoted by automotive associations, OEMs, and policy makers.
- Policy makers seek assistance from both academia and industry (OEMs and suppliers) in funding and developing educational courses that are matched to the needs of industry.
- It needs a holistic approach to tackle the various aspects that are required to increase the number of engineering graduates and people with interface skills.
- Increasing the diversity in the automotive industry is one of these aspects that needs efforts from all involved parties.
- The Government needs to provide funding for education providers going to schools and 'demystify' the engineering profession and thereby, making it more attractive for women. All actors need to intensify their efforts to show girls very early on a perspective in STEM subjects.
- It needs a paradigm shift to communicate a different image and impression of the automotive industry. OEMs, suppliers and industry associations need to convey convincingly that they are genuinely interested in a more diverse workforce.
- Part of that is to be open for people who want to start a 2nd career, considering that there is not only a lack of women in the industry, it is also not yet common for career changers to get the support they need to gain a foothold in the automotive sector.
- OEMs need to intensify their staff retention programmes in order to prevent brain drain after Brexit, which would further exacerbate the skills gap issue.

[26] https://www.theguardian.com/business/2019/jul/09/bmw-engine-production-uk-brexit-fears

[27] https://europe.autonews.com/automakers/jaguar-land-rover-begins-brexit-linked-uk-plant-shutdowns

[28] https://www.bbc.co.uk/news/uk-wales-49156296

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Appendices

Appendix I: The rural digital economy

There are also issues pertaining to digital skills in the context of the rural digital economy, as discussed by the House of Lords Select Committee on the Rural Economy. Businesses in rural areas frequently have difficulty in recruiting and retaining members of staff with the digital skills required for their businesses. Likewise, small businesses and start-ups without these skills can then have difficulty in finding external sources of IT support, thus placing the businesses in question at a disadvantage in comparison to their urban and international competitors. An example of this can be seen in research of the Federation of Small Businesses which found that one fifth of its members who were small businesses had difficulty in finding the staff who had suitable digital skills and that as a result of this they were being held back from the adoption of different digital technology. There was also the problem that opportunities for training for staff were too far away, too expensive, and not suited to the needs of businesses in rural areas. There was also the issue that some rural SMEs were not always aware of the benefits that digital skills and new technology could potentially bring for their businesses.

The DCMS is working with the Country, Land and Business Association (CLA), farming bodies, and operators through the Business Connectivity Forum so as to provide a better understanding of barriers to the take-up of digital technology. Further, the CLA say that "the Forum is working to promote greater awareness of digital technology in central and local government; incentivising the digital industry to focus on reducing the gap between supply and demand by encouraging greater awareness of the benefits of broadband access, and encouraging greater awareness among rural businesses of the advantages of improving digital connectivity and developing digital skills."

Areas of policy consideration may include Government investment so as to improve digital skills in rural areas, the importance of local libraries in access and IT training for rural communities, networking and information sharing, and an increase in incubator hubs and workspaces for start-ups so as to allow for an improvement in networking and information sharing for small businesses. A House of Lords report from 2019 from the Select Committee on the Rural Economy stated that:

"Training opportunities are limited and often too distant or too expensive for rural SMEs to participate in; the case for developing and improving digital skills is not being delivered to rural businesses."

"Local and national governments must do more to realise the potential of improving digital skills in rural areas, including supporting the establishment of digital enterprise hubs; promoting networking opportunities; facilitating knowledge sharing and the dissemination of good practice among rural businesses; and enabling more effective IT support for small rural businesses and start-ups."

The then Minister of State for Digital & Creative Industries, Margot James, described how through the engagement exercise of the Civil Society Strategy it was found that although 72% of charities saw the potential of digital to more effectively deliver the strategy of the organisation, the amount which actually had a strategy as to how digital could assist them in achieving their goals was only 32%. Some of the reasons given for this included a lack of time, capacity, or understanding as to how digital could be embedded at the level of leadership.

A £1 million Digital Leadership Fund was launched by the Government in order that digital skills in the charity sector would be supported and that digital would be embedded in the organisational values by leaders. The Digital Leadership Fund was awarded to 13 organisations, and was open to charities, social enterprises, public sector and community organisations.

Appendix II: Government policies

The Government's key policies in the 'infrastructure' area aim to invest in UK's infrastructure and comprises an increase of the "National Productivity Investment Fund to £31bn" (HM Government 2018: 5), £400m investment in charging infrastructure for electric vehicles, as well as £1bn in the country's digital infrastructure.

'Business environment' forms another pillar of the Government's industrial strategy. Key governmental commitments include a "£16m funding subject to business case for an industry-led national supplier competitiveness and productivity improvement programme" (HM Government 2018: 12). The UK government, the SMMT and car manufacturers set up the Supply Chain Competitiveness programme with the objective "to develop a cross-sector approach to boosting the competitiveness and productivity of the advanced manufacturing sector supply chains in the UK", which resulted in the National Manufacturing Competitiveness Levels (NMCL) (Richmond 2019).

The last pillar of the Automotive Sector Deal is 'places', which comprises the Government's investments in communities across the UK. It includes creation of a "Transforming Cities fund that will provide £1.7bn for intra-city transport" (HM Government 2018: 9). Investments will also be directed to the Advanced Propulsion Centre (APC) that is a "ten-year, £1bn initiative, funded 50:50 by government and industry to support the development of low carbon technologies" (HM Government 2018: 9).

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