European Training Foundation

THE FUTURE OF SKILLS

CASE STUDY OF THE AUTOMOTIVE SECTOR IN TURKEY

DRAFT REPORT, September 2020

THE EU AGENCY SUPPORTING COUNTRIES TO DEVELOP THROUGH LEARNING

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PREFACE

In November 2018 the European Training Foundation (ETF) launched an international reflection to investigate how global trends impact developing and transition economies and to discuss about what actions they need to take to prepare their people for a changing world and manage their transitions towards uncertain futures. The ETF conference – "Skills for the Future: Managing Transition" concluded that monitoring and understanding evolving skills demand driven by new technologies, the prerequisite for greening of our economies and societies, inter-related economies and changing labour markets is indispensable for action. Gathering and assessing reliable intelligence on the evolving skills demand through traditional methods of data collection and analysis and exploration of innovative approaches are essential to anticipate and respond to existing and upcoming changes and to adapt education and training.

This study on the future of skills in the automotive sector in Turkey has been launched following the above discussion. The study aims at investigating how various drivers of change - principally technological ones – impact occupations and related skills in the sector and how education and training adapt to these changing needs. The choice of the sector was based on several considerations. Firstly, in many countries the automotive sector is one which provides relatively skilled, well-paid employment both directly in the manufacture of vehicles, but also indirectly through its supply chains. While being a traditional industrial sector, it is also a sector that is changing rapidly, for what concerns both the product and the production process, with a huge potential to improve the quality of jobs that it creates. Secondly, automotive has important implications for countries not only from an economic perspective but also in terms of environmental impact and of positive technological spill over towards other sectors. Thirdly, Turkey has developed through the years an important experience in automotive, and it is rapidly moving towards the application of innovative solutions to products and components.

The study concentrates on changing skills needs and documents changes in occupations and related skills driven by technological innovation primarily. It does not assess the volume of employment and skills demand, but rather provides qualitative information on occupations and the type of skills required to perform those occupations. The study also provides some information about how companies find (or not) the skills they need and how they reskill their employees to meet the new needs. However, it does not intend to be exhaustive nor to provide in depth information for all occupations in the sector; neither does it assess the supply of skills in the sector. In fact the analysis shows the top professional and associate professional occupations which are most likely to be affected by technological change and also changing skills requirements for medium-and low-skilled occupations, in particular craft and related trades workers (ISCO group 7 such as mechanics, electricians, etc.) and plant and machine operators and assemblers (ISCO group 8). Its aim is to raise awareness about the changing skills demand, identify pointers of change and stimulate a discussion among policy makers and practitioners in the field, so that the findings can be further exploited and used to adapt education and training provision.

The study is part of a series of studies that ETF implements in its partner countries focusing on economic sectors that present niches of innovation and potential for further development. It is based on a new methodological approach which combines the traditional research methods (desk research, data analysis and interviews) with the use of Big Data mining techniques. The use of Big Data analysis is relatively new and experimental, but its application is increasing in the labour market-related research. Despite its limitations, it provides new insights as well as the real-time information on recent trends. The limitations of each research tool are compensated by using a mixed methodology, where the results coming from different research tools are compared and verified from different angles. The result is a consistent set of findings corroborated by different research tools on the emerging trends and technologies in the sector, changing skills needs, new jobs and obsolescent ones and existing skilling and reskilling practices in companies.

Fondazione Giacomo Brodolini and Erre Quadro have been working with ETF to conduct this case study. A group of international and national researchers from the countries were brought together for this project in addition to the ETF's team of experts. The study was carried out between January 2020 and July 2020. This report was drafted by Riccardo Apreda, Liga Baltina, Riccardo Campolmi, Chiara Fratalia and Terence Hogarth, with inputs from the national experts Mustafa Gokler and Süheyl Baybali, and commented by the ETF team (Ummuhan Bardak, Francesca Rosso, Lida Kita and Anastasia Fetsi).

The report documents all steps of the research and presents the findings in a detailed manner. This is because ETF wants to raise awareness of all stakeholders in the partner countries, be it researchers, practitioners or policy makers, about the changings skills needs in the sectors covered by the research. The findings not only raise awareness but also provide food for thought especially in relation to the ability of education and training system to face the changing skills demand and to prepare workers who will be fit for the new jobs and occupations. Shorter and more targeted publications (e.g. policy briefs, infographics, a methodological note) will follow at a later stage after all case studies are completed.

Last but not least, the ETF would like to thank all the public and private institutions, individuals and companies (see list in Annex) in Turkey for sharing information and opinions on the topic, and actively participating in the two ETF's online workshops organised in May 2020 and the final webinar to be organised on the results on 6 October 2020. In particular the sector-specific knowledge of the national experts (Mustafa Gokler and Süheyl Baybali) has enabled ETF to reach to right companies and institutions in the sector which are kindly provided their experiences in the bilateral interviews. This report would not have been possible without their contributions.

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EXECUTIVE SUMMARY

In many countries the automotive sector is one which provides relatively skilled, well-paid employment both directly in the manufacture of vehicles, and indirectly through its supply chains. In the EU, the automotive sector employs around 2.5m people directly in the production of vehicles. Automotive is also the largest manufacturing sector in Turkey, with a long history of producing motor vehicles, either by indigenous companies or major foreign brands investing in Turkey such as Ford since 1929. The sector has played an important role in the transformation of the economy into a relatively hi-tech one with a substantial R&D capability. The ETF study of the Turkish automotive sector has included the following sub-sectors in Turkey:

- manufacture of agricultural and forestry machinery;
- manufacture of motor vehicles, trailers and semi-trailers;
- wholesale and retail trade and repair of motor vehicles and motorcycles.

As such it encompasses both the manufacture of different types of vehicle and sales and servicing (the aftercare market). All actors of the value chain have been included from Original Equipment Manufacturers (OEMs) to the suppliers of components and services. The analysis has focused on all job profiles and skills that are used in the automotive sector and may be affected by technological changes.

The Turkish automotive sector is, as will be revealed, a sector which has experienced relatively rapid employment growth. Currently it is estimated to employ around 600,000 persons directly in manufacturing, sales and service – which has grown substantially over the last decade – plus many more in the supply-chain. It is also a relatively skilled sector given its dependence upon people working in (a) associate professionals / technicians and, (b) craft and related trades jobs. But it is also a sector which faces a number of challenges – not just in Turkey but worldwide – given tremendous technological changes which affect both the products and the processes used to make and service them. Ultimately this has implications for the skills the sector will need.

The findings presented here explore the way in which technological change has affected automotive both value- and production-chains and how this is reshaping the demand for skills in Turkey. It looks at how existing players in the automotive market have had to update their manufacturing methods, selling and servicing the products (vehicles), and how new entrants into the market (such as those specialising in electric vehicles or providing software to control vehicle performance) differ to their predecessors.

The study is part of a larger programme of research led by the European Training Foundation (ETF) which is to considering how developing and transition economies might anticipate and respond to the various changes which are currently spreading through the global economy. In order to identify the way in which technologies are shaping the demand for skills in the automotive sector in Turkey, the study included the following research steps:

1. a review trends in output, employment and skills based on national statistics and various existing reports (national and international);

2. big data analysis using text mining techniques to collate data on emerging technological trends from patent data and scientific papers, and identify the skills associated with those technologies;

3. interviews / focus groups with selected automotive companies and key stakeholders to understand the factors which facilitate or inhibit the take-up of various technologies and the development of the skills need to use them.

As such the study provides a comprehensive, forward looking assessment of skill needs in the automotive sector in Turkey.

Drivers of change and emerging technologies

People work with technologies and this as a large bearing on the skills they will need to use whatever technologies are used in the workplace. To derive a list of technologies used in automotive workplaces – and how these are changing - requires an analysis of the drivers of change. This helps focus upon the technologies which are most likely to affect products and processes in the automotive sector and, ultimately, the demand for skills. Big data analysis, combined with insights from desk research, identified the following drivers of change in Turkey's automotive sector.

- **Introduction of new technologies,** both for what regard to the products (electric cars, smart cars, etc.) and production processes (e.g. Industry 4.0, etc.).
- **Emergence of new business models,** from online trading that will remove intermediaries and increase customisation, to shifts towards renting or sharing vehicles rather than buying them, which is increasingly leading to the 'servitisation' of the automotive market.
- **Integration with Global Value Chains (GVC),** with its positive effects in terms of growth, know-how, and best practices. A related topic is that of **design:** companies able to develop original components, say, electric cars, can upgrade their position in the GVC towards the higher valued-added segment and increase their competitive advantage.
- **Complexity of the GVCs and the increased relevance of logistics,** with the related topic of the governance needed to manage such complex supply chains and logistics.
- **International competition,** which leads to the adoption of solutions to improve efficiency, reduce costs and maintain quality levels. Competition is being intensified by the entry of new players such as Google or Tesla with their electric-autonomous cars.
- **Increasing customers' expectation and customisations of products,** which leads companies to work on differentiating their products, and on customer satisfaction, by improving business processes and introducing innovative solutions.
- **Economic and political (in)stability,** affecting foreign investments, domestic market revenues, and conditions of access to (some) international markets.
- **Public policies and incentives,** supporting, for example, the development of specialisation in electric cars production.
- **Standards/regulations,** which often prompt the development or the implementation of innovative technologies, for example, those designed to cope with environmental regulations.
- **Safety requirements,** always a focus of the industry, now becoming relevant in relation to the public perception of autonomous driving cars.
- **Environmental impact:** there is an increasing concern for corporate environmental responsibility and the introduction of numerous public policies to control car pollution.
- **Privacy concern:** in the era of connected vehicles, the violation of privacy requirements is an emerging issue that automotive companies need to consider.
- **Increasing limits on the use of fossil fuels** which leads to the growth of interest in using alternatives to fossil fuels as an energy source for vehicles.
- **Impact of COVID-19:** while in the short term companies experienced various problems due to the pandemic, in the long term the shock may lead to positive effects, because it prompted the emergence of new business models and opportunities, as well as a return to local production that

will benefit Turkey (being closest to Europe's GVC). It has also accelerated the introduction of digital technologies and automation.

The various drivers listed above have implications for the types of technology used in the automotive sector. The text-mining analysis revealed that (i) electric vehicles, (ii) 3D modelling and (iii) artificial intelligence (AI) were the three technologies where there has recently been a relatively large number of patents filed, indicating that these technologies are likely to be increasingly used in the future. The more comprehensive list below of technologies increasingly coming on stream, indicates multiple technologies related to innovative and disruptive solutions and also to more conventional technologies (e.g. materials, structural parts) that are important to the sector and are objects of developing innovative solutions (e.g. wheel systems, mechanical power transmission, door systems, etc.).

- Data processing
- Mechanical power transmission
- Wheel systems
- Internal combustion engines
- Sensor control systems
- Door systems
- Materials
- Seat systems
- Load-carry vehicles
- Structural parts
- Suspensions
- Braking systems
- Electrical systems
- Manufacturing systems
- Air conditioning systems
- Lighting devices
- Steering systems
- Safety systems
- Wipers systems
- Car body systems
- Electrical propulsion systems
- Lifting devices
- Cabin systems
- Servicing cleaning

From technologies to skill needs

The capacity of the automotive sector to obtain maximum benefit from new technologies depends on the availability of skills to facilitate their introduction, use, and maintenance. To identify the skills attached to the technologies listed above, a further round of text-mining was undertaken on two online databases which contain detailed information on the skills which comprise occupations: (i) the European Competences, Skills, Qualification and Occupations (ESCO) database; and (ii) the Occupational Information Network (O*NET) database from the USA. As these databases do not contain emerging (future) jobs or new skill needs, another source – Wikipedia – was used to identify the signs of emerging skills.

The results show the jobs where the skill content is most likely to be affected by technological change and then looks in more detail at the skills within those jobs which are attached to various technologies. The jobs which are likely to be most affected by technological change are:

- **engineering professionals, in various fields:** electrical, mechanical, sensor, mechatronics, optoelectronic, industrial, automation;
- **information and communications technology professionals** (user interface developer, industrial mobile devices software developer, ICT system developer or ICT network engineer);
- **technicians and associate professionals** such as robotics engineering technicians, industrial robot controller, and motor vehicle engine tester;
- **skilled blue-collars and grey collar workers** (assemblers and operators for various types of components and machines, and tradesmen such as electricians, mechanics, and welders).

Neither the big data analysis nor the interviews with employers and stakeholders highlighted the impact on managerial and sales roles – although interviews often pointed out the need for a mentality that was more open to change will become increasingly necessary for people working in sales and management jobs in automotive sector.

The impact of technological change will affect people working at all levels in the sector, requiring them to possess a wider set of skills than presently in order to accommodate the introduction of the new technologies. The study also highlights the importance of what have been referred to as 'grey-collar' workers – the category in-between blue-collar and white –sometimes referred to as technicians in other countries. The importance of grey-collar workers implies the upskilling of existing blue-collar ones indicating that higher levels of edification and training may be required to be fully competent in these jobs. It also suggests a shift in the occupational structure towards more people being employed in medium and high-skilled jobs, with much fewer in low-skilled ones.

The changes described above are transforming the content of existing jobs in the automotive sector and its occupational structure. In relation to electrical engineers for instance, there is a potentially wide range of areas where skills will need to be acquired to master the use of various technologies (for example related to the use of a wide range of sensors in the case of electrical engineers). It is also apparent that entirely new professions are emerging, typically at the boundary between disciplines or as a result of new technologies which are driving change in the sector. These new jobs include, for example, "Energy market analyst" and "Battery algorithm engineer".

The new skills needed to master the interface with new technologies will also affect the role of more traditional jobs in automotive such as welders. While the traditional skills of welders ranges from knowledge of basic welding equipment and common welding techniques up to visual inspection competencies, the information collected from the interviews with key stakeholders and employers revealed that welders must now possess a wider range of knowledge, including, for example, deeper knowledge on material properties, a higher digital capability, and must also speak fluent English.

Not so many occupations show signs of obsolescence. Data mining analysis and companies' interviews seem to reveal that, even if the digitalisation is disruptively changing the sector and some activities will be substituted by automation, most of the professions will be digitally converted and upskilled. Accordingly, while low-skilled manual tasks will most likely disappear, the incumbents of those will not be substituted by automation but, instead, will be trained in new skills to enter more skilled jobs.

To sum up, the evidence indicates that the majority of new workers will need to possess a wider range of skills than hitherto (a shift from low-skilled to medium-skilled ones). In particular the interviews with companies pointed to the increasing relevance of multi-disciplinary competences and the ability to interact with people from different disciplinary or professional backgrounds, as well as the emergence of "T-shaped" profiles, with core competences in one area coupled with additional skills and knowledge in various other subjects, or even "comb-shaped" profiles, with deep knowledge in various different vertical areas.

Responding to change: the views of stakeholders

The data-mining has expanded the knowledge base on new and emerging skills, but there is still a need to understand, from the perspective of those connected with the automotive sector, their views on emerging skill needs, and their experience of obtaining these skills to date. The interviews with the key stakeholders and companies revealed the following results:

- All the sector representatives confirmed the results of text-mining and recognised that the sector is undergoing a period of advanced technological change as outlined by the big data analysis. So, the interviews showed no contradiction with the text-mining results, rather they provided complementary information.
- Most companies indicated that the shortage of skilled workers in the automotive sector was the main limiting factor to company growth. There are shortages for white-collar workers with technology specific competences - in particular those related to digital and ICT professionals – and shortages for grey-collar workers (i.e. medium-skilled workers). Companies also pointed out that the education system is producing workers who have gaps in the knowledge base. University graduates, for example, have gaps in their practical knowledge, and those exiting vocational courses are not sufficiently skilled in new technologies (i.e. those relevant to grey-collar roles).
- Recruiting people with the skills needed to adapt to technological change can prove difficult because of: (a) a general mismatch between what is expected by companies and what is the offered by the educational system; (b) for some profiles (e.g. ICT and data-related positions) the relatively low attractiveness of the sector compared with other sectors, but also the fact that many highly skilled workers (including engineers) leave the country to work abroad.
- Many of the firms in the sector are engaging in the training of their workforces (upskilling and re-skilling) so that future skill needs will be met. In certain cases, the training is aimed at providing more practical knowledge, in others at learning new technologies or upskilling blue-collar workers to cover grey-collar worker positions. Having more detailed information on skills needed helps them in the adaptation process and may well help to stimulate the supply of highly sought-after skills.
- Respondents said that universities and vocational education and training providers in Turkey are often not sufficiently knowledgeable about the realities of the sector – but this tends to be a common complaint across Europe.

Improving skills anticipation

The use of a mixed methodological approach – combining desk research, data analysis and interviews with data-mining techniques and interviews with stakeholders and companies – provided information on emerging skill needs derived from sources which until recently have been out of reach of skills researchers. Therefore, the report has identified the key technologies that drive skills demand over the short- to medium-term, and a variety of occupations which will be most affected by technological change. Particular attention is given to specific technologies shaping the skills needs within specific occupations and the new skills which are currently not included in the existing occupational classifications.

This is not the end of the process. The report raises questions for further research; e.g. information on the scale of demand, whether that demand is likely to be met, the impact of unmet skills on the sector and the economy, how the supply-side needs to respond and how training providers can be supported to deliver the skills automotive needs and thereby reduce any skill shortages / bottlenecks.

By identifying the specific skills which will affect a variety of jobs in the future, it is now possible to feed this information into, for instance, skills forecasting and skills foresight exercises, and into the design of employer skills surveys. The latter can help identify the volume of demand for specific occupations/jobs, the actual combinations of skills which are required within those jobs, and the magnitude of any skills shortages.

Given the high speed of technological advances in some sectors such as automotive, it is necessary to periodically repeat the analysis carried out in this study. But it is also important that representatives from the sector are involved in the assessment of skill needs and agree on how skill needs might be met. In this way the automotive will be better placed to proactively respond to the changes which are affecting the demand for skills.

1. INTRODUCTION

As already mentioned in the preface, this report presents the first ETF case study on the future of skills in the automotive sector in Turkey. It gives the results of our investigation – conducted between January and July 2020 – on how various drivers of change – principally technological ones – have affected and will continue to affect jobs and skill needs in this automotive sector. It will raise awareness about the changing skills demand and stimulate a discussion among policy makers, practitioners and researchers in the field, so that the findings can be further exploited and used to adapt education and training provision.

The report is organised as follows. Section 2 sets out the analytical framework of the study and outlines the key steps of methodological approach used in the study – though a detailed explanation of the general methodological approach is published separately. This is followed, in Section 3, by an overview of the automotive sector in Turkey and its employment potential and occupational structure based on the literature review and secondary analysis of official employment statistics (labour force survey). This provides a good level of contextual background of the sector for readers before going into the details of big data analysis and company interviews.

Section 4 is based on the text-mining exercise and goes on to analyse the main drivers of change affecting the sector and the technological changes which are beginning to take root, and how these are likely to influence future skill needs. Using data derived from the text mining, combined with information obtained from the in-depth interviews with key stakeholders and selected innovative companies, section 5 provides information on emerging skill needs and their impact on occupational job profiles. Section 6 outlines how the companies have responded to observed changes and met their emerging skill needs, including their strategies involving education and training providers and research centres. The section finishes with a final word on the findings.

The report also includes a list of key stakeholder institutions in Turkey that were consulted for the study (Annex 1), a glossary to set a standard definition of labour-related concepts and better explain some technical terminology (Annex 2), and a detailed bibliography.

2. METHODOLOGICAL APPROACH

The overarching purpose of the study is to understand the drivers of change affecting the automotive sector in Turkey, ascertain the technological changes which are either taking place or about to take place, and identify the resulting skill needs. The study is about understanding the links between technological change and skills demand so that policy makers can better respond to emerging skill needs. The initial research questions which provided the framework of the study are shown in Box 1.

Box 2.1: Specific research questions of the study[1]

Questions about the state of development in the analysed sector

1. What is the relationship of the selected sub-sector to the whole sector and the broader economy (e.g. production, employment, export)?
2. What are the main drivers of change currently shaping the sector (e.g. trade, global value chains, new technologies, digital tools, the climate change)?
3. What has driven/generated innovation in this part of the sector and does it have the potential to become an influence on the rest of the sector?

Questions about the empirical evidence on the changes occurring in the sector

4. What are the ongoing changes observed in the sector in terms of production, storage, marketing, and business practices, labour, and skills utilisation?
5. What are the main occupational profiles used in the sector? Has the content of some occupations evolved as a result of the above changes in the sector, how?
6. Which new tasks and functions have emerged in the jobs and/or occupations in this sector? Which old ones have disappeared?
7. What are the differences in the job profiles of this innovative sector? What changes are observed in the profiles of new recruitments and job vacancies published?
8. What is the impact of these changes on labour and skills demands in the sector? Do changes require higher levels of the same skills or completely new sets of skills from workers?
9. How do these changes affect 'skills utilisation' and working conditions in the sector (e.g. salary, contracts, working hours, formality)?
10. How do businesses meet their new skills needs (new hiring, retraining, etc)? Are there initiatives/ cooperation of companies with education and training providers?

Questions about policy implications

11. Do technology, innovation and other changes push countries toward a higher added value and integration in the global value chain? Are skills contributing to this shift? If so, how?
12. Are there any spill-over effects from the changes in the overall broader sector? What context-specific and general lessons can be derived from these studies?
13. Are changes and innovation in the sector causing education and training to respond and to adapt to industry needs?

The term "automotive" is intended here with a wide definition of the sector: first, in the perimeter of investigation are included all motorised vehicles meant for transport on road, from motorcycles to trucks; second, both the products themselves (including of course the new categories such as electric or self-driving cars) and their production processes (from standard assembly to additive manufacturing) have been considered; third, all actors of the value chain have been studied, from OEMs to suppliers of components and services. From the occupational point of view, the focus has been on all job profiles and skills that may be affected by technological changes, regardless of the level of skills or role in the companies. In summary the study encompassed the overall value chain of the sector and the entire production system, including the changes which existing manufacturers need to make to their production systems, as well as the role of new entrants to vehicle manufacture (e.g. Tesla) and the

[1] The last three questions have been the most difficult to answer since none of the respondents provided much insight which could be used in the analysis.

supply-chain (e.g. those providing software to control vehicle performance) which differ from their predecessors in the types of activity which they undertake.

Given the need for the study to be forward looking, a mixed methodological approach is used – combining desk research and data analysis with data-mining techniques and interviews with stakeholders and companies (Box 2).

Box 2.2: Steps of the mixed methodological approach in the study

1. Well-established methodologies derived from social science, including:
   - a literature review of the automotive sector in Turkey;
   - secondary analysis of employment and skills data, in particular in the sector;
2. Big data analysis in relation to the automotive sector in Turkey:
   - text-mining applied on a large volume of documents such as patents or scientific papers connected to automotive in order to identify the technologies (and other drivers of change);
   - comparing and matching the list of relevant technologies extracted from text-mining to the related occupations and skills listed by the occupational databases of ESCO[2] and O*NET[3], by using semantic matching algorithms;
3. In-depth interviews with companies and key stakeholders in the automotive sector to verify and refine the results of the two previous steps of analysis.

The ***first step*** of the study was a review of the literature on innovation, employment and skills pool in Turkey in general, followed by a description of the automotive sector, its innovation and employment capacity and the skill needs in particular. Based on the data provided by Eurostat, the Statistical Office of the European Union, and also TURKSTAT, the Turkish Statistical Institute, it was possible to make some estimates of the workforce in the automotive sector, including its magnitude and changes over time in terms of occupational groups and qualifications and skill demand. This contextual analysis demonstrates that the capacity of the automotive sector to introduce the latest technologies does not rest only with skills policies, but also with obtaining investment capital, having links with research institutes, and offering relatively good jobs to attract those with necessary skills.

The ***second step*** was text-mining, a technique that allows computers to extract, discover or organise relevant information from large collections of different written resources. Indeed, the textual documentation produced by industries, institutions, research centres, and the like produces a vast amount of information. However, this is often scattered among many sources and the sheer volume of existing documents makes it impossible for manual search. And even if it could, it is likely that some data would be missed. For this study, a proprietary text-mining tool was used to scan the largest possible corpus of data in **English**. Algorithms using natural language processing, amongst other techniques, are able to extract and record the number of incidences where a technology (or other relevant entities such as occupations, country names, etc.) is mentioned, and keep track of all the inter-relationships between key terms.

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[2] **ESCO** - is the **E**uropean multilingual classification of **S**kills, **C**ompetences and **O**ccupations. ESCO works as a dictionary, describing, identifying and classifying professional occupations, skills and qualifications relevant for the EU labour market and education and training, in a format that can be understood by electronic systems. It lists over 3000 occupations and 13.000 skills and competences). For more info, see https://ec.europa.eu/esco/portal/home.

[3] **O*NET** stands for Occupational Information Network is a free online database of occupational requirements and worker attributes. Currently the online database contains 1016 occupational titles, each with standardised and occupation-specific descriptors, covering the entire U.S. economy. It describes occupations in terms of the skills and knowledge required, how the work is performed, and typical work settings. It can be used by businesses, educators, job seekers, human resources professionals, etc. It is a program to facilitate the development and maintenance of a skilled workforce, developed under the sponsorship of the US Department of Labor/ Employment and Training Administration (USDOL/ETA). For more info, see https://www.onetonline.org/.

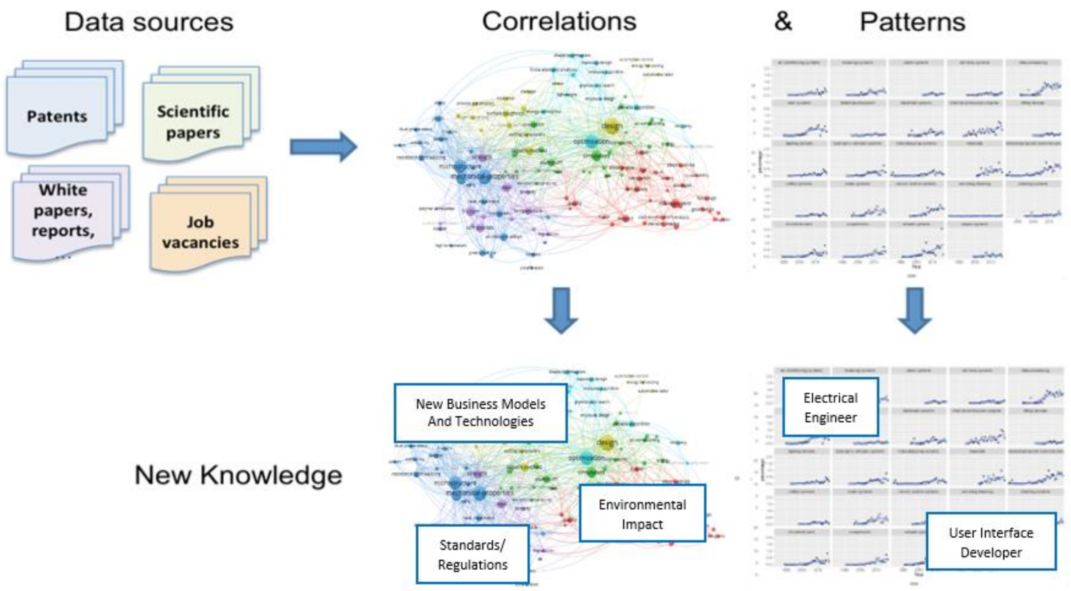
Key sources used for the text-mining analysis were patents and scientific papers in English. They are large and accessible corpora of structured data, which is extremely important for the reliability and completeness of results. Patents are widely considered as a good proxy for measuring innovation anticipating technological changes, while papers and conference proceedings allow to also study social and economic factors. For patents, data were taken from Espacenet, the official database of the European Patent Office, regarded by many as the most authoritative source of patent information, containing over **120 million documents** from around the world and updated daily. For scientific papers, data were searched in both Scopus (by Elsevier) and Web of Science (by Clarivate), the two largest databases of peer-reviewed papers, where an equivalent study was performed on around **70 million scientific papers**. In addition, **hundreds** of white papers, policy papers, project reports or foresight papers from Turkish and international institutions, as well as web pages dealing with automotive topics were searched on the web with standard queries and downloaded to be analysed. But they were much fewer in numbers, unstructured and sometimes of promotional nature, so not as relevant as patents and papers.

These data were processed with proprietary algorithms to harmonise inventors, authors, companies and universities names, and to consolidate the geo-localisation of parties according to NUTS codes. The latter is clearly relevant when interested in country-specific studies. To maintain the focus on Turkey, two types of patents were selected: those issued directly by the Turkish Patent Office, and the international ones for which at least one of the assignees was located in the country. Papers instead were selected if Turkey was cited among the countries of interest for the study. The Erre Quadro's semantic algorithms were able to recognise functional concepts rather than simple keywords, so they were used to scan the full text of each document to identify those with a main focus on 'automotive'. Documents were retrieved since 1945, but for many analyses only the last twenty years of data were used. This is a good time window considering that a restriction to even more recent periods would have obscured most temporal trends.

The first phase of this text mining identified two main categories of relevant information: (i) technical and societal drivers of change; and (ii) technologies introduced into the sector and their diffusion over time. In the second phase of text mining, the information identified was compared and matched to the associated occupations and skills listed in the databases of ESCO and O*NET, using semantic matching algorithms (i.e. algorithms able to find semantic connections between different concepts based also on contextual information). For example, each occupation in the ESCO database includes a description and a list of competences, skills and knowledge considered relevant (either essential or optional) for that occupation. The semantic algorithm looks for matches of each technology with all the concepts associated with that occupation. When a match is found, the occupation is considered associated with the technology. The entire procedure is automated by using ESCO's API, which allows occupational data to be downloaded. If an occupation is impacted by technology at any level, then the text mining finds it. If no match is found in ESCO or O*NET due to emerging (future) jobs or new skill needs, other approaches – e.g. connecting the new competences through Wikipedia – were used in order to try to identify them.

The main advantage of text mining is the ability to search quickly a very large number of documents in real time. Particularly patents and scientific papers are easy to access and structured (compared to social media), so information extraction is facilitated. Although information may be scattered over many different documents, algorithms are able to discover hidden patterns and emerging phenomena which might not be detected by manual search techniques. Correlating concepts and extracting trends allow weak signals to be detected and emerging trends to be spotted (see Figure 1). This gives a future-oriented perspective and hints at what is not already known from the past. Anticipating the future from the extrapolation of past trends, even with the most sophisticated forecasting models, is likely to fail if the phenomenon of interest is subjected to rapid and disruptive change. Text mining at least provides a basis for identifying the variety of disruptive factors which can be then explored with key stakeholders. This is particularly important when thinking about the skill implications of technological change because there is an element of entering the unknown.

Figure 2.1: Text mining extracts correlations and trends from the data, which can be turned into knowledge about the future of skills and job profiles



<u>The ***third step***</u> was a complementary qualitative research to obtain information from key stakeholders and companies about their experience of technological changes and other change drivers in the sector and the new skill needs arisen. Due to the Covid-19 pandemic, **focus group** discussions were convened online in May 2020 comprising all relevant stakeholders from: (a) the automotive sector; and (b) the educational and training system. In total more than **50 representatives** from governmental institutions, academia and research, as well as public and private associations and organisations attended the two focus group discussions. The purpose was to reflect upon the results from the previous steps. After the focus groups, online in-depth interviews were conducted between May and June 2020. A semi-structured interview technique was used to guide the discussions.

Following the focus group discussions, two additional online interviews with selected stakeholders were conducted to explain more in detail how technological change impacts the skills needs of the automotive sector and the acquiring the skills the sector needs. A full list of key stakeholders and company representatives participating in online focus groups (as institutions, not individual names) is provided in Annex 1. The names of individuals from these institutions are not included for data privacy reasons.

The main target group for field work interviews was the selected innovative companies in the sector, to understand their perception and actions in managing the technological change process in the companies and ways of finding the skills they need. The text mining from patents allowed to identify the top five innovative companies (as measured by the highest patent filing in recent years) for each technological cluster or subsector which emerged during the analysis. The companies which were the Turkish branch of a multinational with headquarters in another country were removed from the list, as were the patents filed by universities and governmental centres. This led to identify around 30 Turkish companies. This list was also cross-checked for the 10 most active companies overall (i.e. not distinguishing by subsector when counting patents filed), since companies which are transversally innovative over different subsectors are surely of interest. The list was manually revised to check for duplicates or for mergers & acquisitions and to keep the variety over subsectors. Finally, the national expert integrated the list with other candidates, and the resulting 48 selected companies were contacted.

In total sixteen companies were interviewed from the sector, covering the widest possible spectrum of automotive activities and including enterprises of different sizes and types. Whenever possible, the interviews were conducted with multiple key personnel within each company (including managers, R&D heads, HR specialists, etc.) and the questions focused on how companies deal with the process of technological change (including barriers to its implementation such as shortages of capital and skills), and the impact upon the content of jobs and the related skills needs emerging from these changes.

Collecting the views of key stakeholders and interviewing the selection of innovative companies was an important step since new skill demands can be revealed only by understanding the responses of companies to the signals about emerging technologies. Arguably, interviewing innovative companies may not provide a fully balanced picture. However, the study aimed to collect evidence on how the technological changes affect, if implemented, employment and skills. Thus, it looks at the changes in occupations and necessary skills to perform these occupations, not the volume of skills demand. Accordingly, studying the segment at the frontier is the key to shed light on the changes that the other actors will have to follow. In general, there was no contradiction between the results of text mining and interviews. The report specifies when the interviews simply confirmed text-mining results, and when the interviews provided complementary information to the text mining.

Combining different research methods brought some advantages, as no single methodology can identify all the emerging skill needs in the automotive sector. Different techniques complemented one another, each compensating for the others' potential shortcomings. The results from different research tools were then compared, verified and complemented. For example, companies' product market and skill strategies were difficult to collate by text mining, but they could be derived from reading their annual reports and interviewing key personnel. But these were not always ideal sources to find out about the technologies which are transforming or about to transform products and processes in their sector, as companies might simply be unaware of them. Text mining identified technologies which are likely to have a major influence on companies' strategies in the future – in addition to other advantages of text mining discussed above.

Nevertheless, there are ***certain limitations*** of this study which need to be acknowledged:

- The information provided by companies and other key stakeholders should be regarded as indicative rather than definitive given the small number of people interviewed in the study. Future studies could include more interviews, with a more representative selection of companies and stakeholders, but this tends to be resource-intensive and costly.
- The text mining was limited to searches in English. Turkish, for example, was not used in the searches. It is likely to be the case, however, that most of the patents and scientific papers are published in English in this period. For future analysis, there is scope to extend the text-mining tool to other languages so that it can search in any language.
- Despite the mixed methodological approach used in the study, this report is not able to give an indication of the scale or volume of any change in jobs and employment (e.g. it is not able to say how many extra electrical engineers will be required), or the relative importance of particular skills, or the extent of any skills mismatches. Other methodologies are required to address these issues.
- Patents are proxies for innovation and tend to be concerned with emerging technologies (e.g. patents are often filed to protect an innovation that is just about to come on stream). But it is possible that some of innovation is not patented. Moreover, patents are mainly linked to technological innovation. Non-technological innovations (e.g. those of business models) are also

important; the review of scientific papers and interviews with companies and stakeholders were the tools to capture other drivers of change.

- The analysis of skills is limited to those which are associated with technologies and other trends identified by the text mining. If a certain technology is linked to occupations and skills at any level in ESCO and O*NET databases, this is captured. There might however be cases in which the association with a new technology is not yet included and has to be determined thanks to interviews or other strategies.
- If there are completely new (future) occupations and new skill needs, they are not found (yet) in the existing databases of ESCO or O*NET. In these cases, other non-conventional data sources such as Wikipedia were used to access and identify information beyond the traditional structured ones, when considered non exhaustive. However, it is clear that the information provided by these types of sources should be handled with care.

Whenever possible, these limitations have been partially compensated by cross-checking results with existing similar studies published over the recent past. In this case, findings and considerations from other research studies have been analysed and taken into account to fill in the gaps and provide more details to provide an overview of sectoral information and skill needs and evolution as exhaustive and as accurate as possible.

Despite these limitations, the data science approach brings some added value. It builds on the conventional forms of skills analyses such as undertaking skills surveys and carrying out skills forecasting. It allows to identify the skill content of jobs in the automotive sector and possible changes of skills with new technology. Thus, the focus is on actual jobs and how these will change over the short- to medium-term, rather than broad aggregations of jobs into occupations. Data is captured on specific skills in specific jobs rather than total demand for certain occupations. The approach is flexible, and the algorithms can be run and re-run in a relatively speedy manner. So, if a sudden economic shock or a crisis of some kind emerges – such as Covid-19 – the analysis can be quickly rerun to capture the effects of these (so long as there are data which can be searched).The report was carried out during the outbreak of the Covid-19 pandemic, which brought a high degree of uncertainty regarding the future of employment and skills demand. As the study is concerned with the long-run development of skill demands resulting from technological change, the findings are less sensitive to changes over the shorter-term with immediate and direct impact. The pace of change may slow down or accelerate as a result of the pandemic, but the nature of that change is likely to remain the same. At least the uptake of automotive technologies (e.g. automation, robots, sensors) may be accelerated in the medium term in some countries, due to the Covid-19 experience of high dependency on importing goods from overseas (i.e. raw materials, components and spare parts), and on the need of not relying on manual labour too much. It would not be surprising to see if some countries or multinational companies re-shore automotive production from low-cost regions to higher-cost domestic markets (so-called ‘deglobalisation’) to guard against future supply-chain shocks. Thus, the contribution of innovation could be perceived as more important (or even essential) in the plans of some countries for a more localised production. Finally, the shift to a more localised production can become a competitive advantage for Turkey thanks to its closeness to its market of reference, i.e. the European Union.

3. OVERVIEW OF THE AUTOMOTIVE SECTOR

KEY ISSUES COVERED

- Recent trends in the Turkish economy
- Changes in the overall demand for, and supply of, labour and skills
- Employment in the Turkish automotive sector
- Drivers of skill demand in the automotive sector

The purpose of this chapter is scene setting by providing an overview of recent developments in the economy of Turkey and how this affected the overall demand for employment and skills, followed by the employment and skill developments in the Turkish automotive sector – both its manufacturing arm and that relating to sales and servicing. The chapter will demonstrate that the automotive sector is an important one in Turkey given recent levels of output and employment growth where the latter is often into relatively skilled jobs. The skills system is not ideally positioned to meet the sector's skill needs given that the relatively few people with intermediate level qualifications in the country (i.e. those at ISCED levels 3 and 4). For comparison, other countries with substantial automotive sectors tend to have education and training systems which produce proportionately more with qualifications at this level. The automotive sector in Turkey is much more dependent upon people with a basic level of education (i.e. at ISCED levels 0 to 2), which may have negative implications for its capacity to respond to future technological changes.

3.1. The economy

The economy has experienced relatively rapid growth over the last 40 years driven by policies which have concentrated on stimulating domestic demand which has brought about substantial job creation especially in services. As a consequence, GDP per capita has nearly tripled since the early 2000s, something which has been sustained by the transition from (informal) agricultural activities towards industry and services. This has removed many people out of poverty and moved the country to be an upper middle-income one.4 The World Bank points out that few countries have been able to achieve this degree of progress in a relatively short space of time.

While growth has been relatively strong, it has also shown much fluctuation with, more recently, concerns expressed about the degree of macroeconomic stability given sharp currency depreciations and high levels of inflation (see Figure 3.1). Following the 2018/19 downturn – largely a result of the trade war with the USA - which revealed the country's vulnerability to external shocks, there is now more focus in economic policy on measures to steady the economy. This has brought about an increased policy emphasis on long-term productivity growth, innovation, and human capital development.5 The COVID-19 crisis will be likely to have significant effects on the global and Turkish economies. Evidence of Covid-19's impact is still uncertain, but early evidence indicates it will constrain economic growth. In May 2020 industrial production in Turkey was down 19% on one year earlier.6

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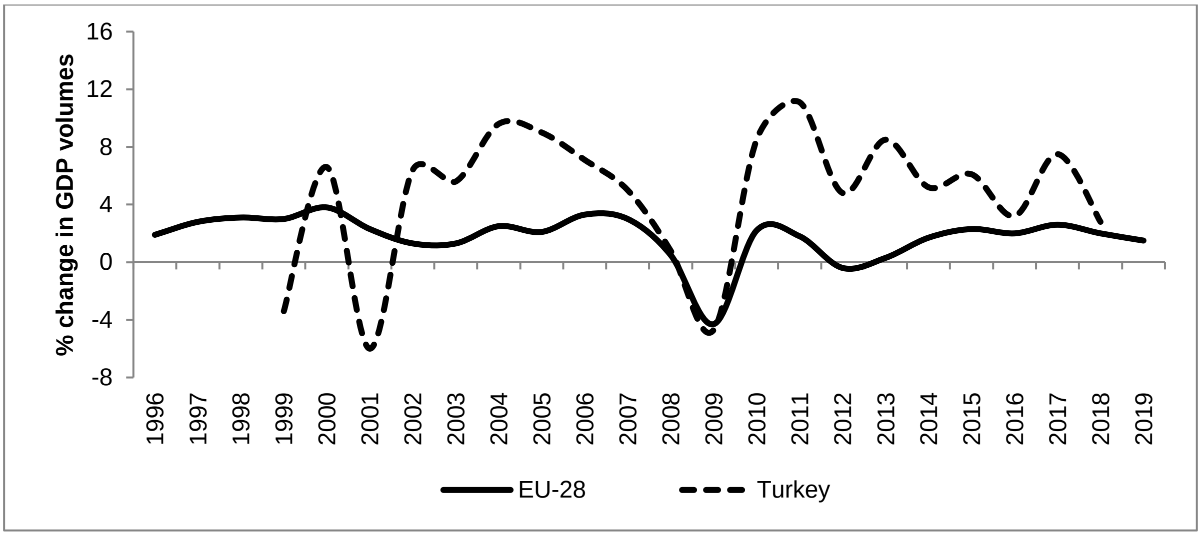
4 The World Bank (2019). *Firm productivity and economic growth in Turkey: Turkey Productivity report 2019.* Washington: World Bank Group

5 OECD (2018) *Economic Survey: Turkey*. Paris: OECD

6 http://www.turkstat.gov.tr/PreHaberBultenleri.do?id=33800

Figure 3.1: Percentage change in GDP growth, 1996 to 2019



Source: Eurostat – GDP data

Turkey is an open economy. In 2017, it exported goods and services worth $166 billion, making it the 27th largest exporter in the world, and imported $214 billion, making it the 20th largest importer in the world. The trade imbalance has placed pressure on the economy to improve its competitiveness.[7] The automotive sector plays an important role in trade accounting for nearly 8% of all exports from Turkey. The main destinations for automotive products are Germany (14%), France (12%), Italy (10%), the UK (8%), and Spain (6%).[8]

3.2. The labour market

As noted above, Turkey has been able to create many jobs over the recent past which has absorbed people moving out of the agricultural sector. Figure 3.2 reveals that the country has consistently outperformed the EU in employment growth. An indication of the economy's development is indicated in the level of the national minimum wage. In 2015, it stood at 424 EUR/month; a 59% increase from the value of 266 EUR/month registered in 2005.9

Although the economy has developed substantially over the recent past, activity and employment rates have remained below the EU-28 average and unemployment rates have been higher. This suggests substantial excess capacity in the economy. The capacity of the labour market to absorb future growth is reinforced by demographic trends. The population in Turkey has been increasing, since 2013, by more than 1 million people a year. The population of the country is a relatively young one: in 2017, half of the population was aged under 32 years.10 Population growth has also been boosted from the inflow of refugees from neighbouring Syria. More than 3.6 million people have fled to Turkey since 2015.11

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7 https://oec.world/en/profile/country/tur/

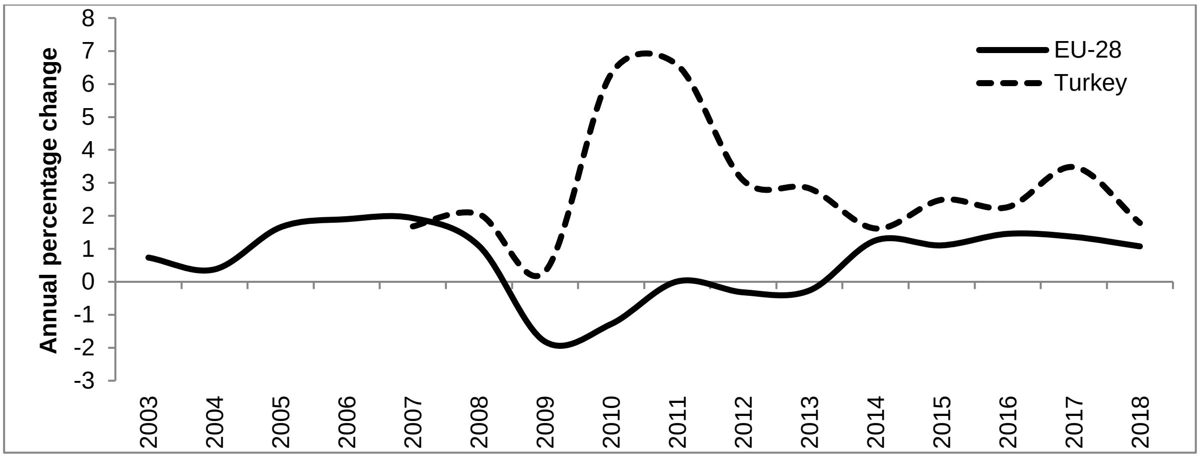
8 Source: Turkish Statistical Institute, Export database. Data extracted on 20 April 2020

9 Eurostat.

10 Eurostat, Population change - Demographic balance and crude rates at national level [demo_gind] and Eurostat, Fertility indicators [demo_find]. Latest data figures available for the year 2018.

11 UNHCR.

Figure 3.2: Annual percentage growth in employment, 2003 to 2018



Source: Eurostat – Labour Force Survey

There are a number of acknowledged weaknesses in the labour market.

- There is a high level of informal and undeclared work in the economy which has been exacerbated by a strong inflow of refugees. It is estimated that around 27% of output is accounted for by the informal economy.12 The sizable informal economy is seen as drag on productivity (Taymaz, 2009).
- There is a persistent geographical divide affecting the Turkish economy and labour market, especially that between eastern and western parts of the country. In the westernmost provinces (where the automotive sector is concentrated), GDP per capita is roughly five times higher than in provinces of the east.13
- There are significant gender and age gaps with respect to participation in the labour market. For example, the labour force participation rates for men aged 15-64 years of age was 70.9% in 2018 compared with 32.9% for women (a gap of 38 percentage points).14
- Women are disadvantaged in their access to the labour market. The employment rate for men at 71% is far higher than that for women 33% (2018). Women are more likely to work in the informal sector which means they are more likely to experience relatively limited access to skills training.15

All of the above points to spare capacity in the labour market to meet the demands of future growth.

3.3. Skills[16]

The level of skill demand can be obtained from looking at the occupational structure of employment and levels of educational attainment of those in employment aged 15-64 years. Figure 3.3 shows that

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12 European Commission (2019) *Economic Reform Programme: Turkey*. Brussels: Commission of the European Communities SWD(2019)

13 MoNE (Ministry of National Education), Turkey Torino process report 2018–2020, May, 2019, https://openspace.etf.europa.eu/trp/torino-process-2018-2020-turkey-national-report

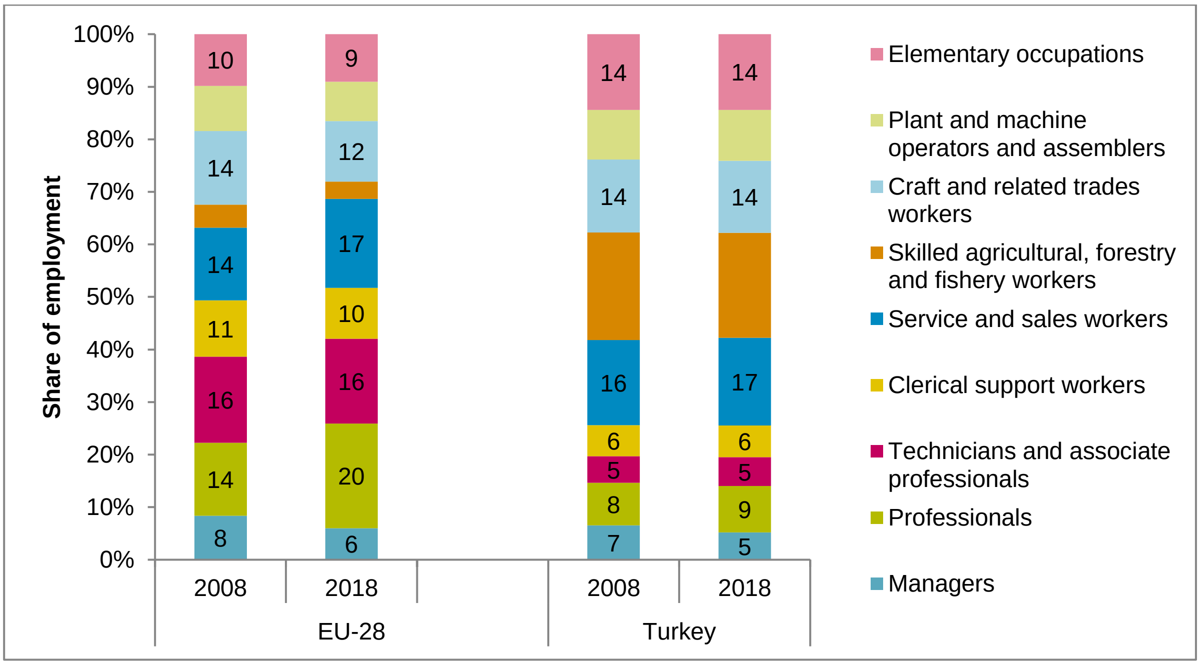
14 Eurostat, Employment rates by sex, age and citizenship (%) – Labour Force Survey statistics [lfsa_ergan]

15 European Commission (2019) ibid

16 Skills in this context is defined as the ability to apply knowledge and experience to complete tasks and solve problems related to work. Although not always corresponding, the education levels of people are used as proxy for their skills levels in the analysis, such as the high-skilled (ISCED 5 and above), the medium-skilled (ISCED 3

the percentage of people in high-skilled jobs (managers, professionals, and associate professionals) is relatively low compared with the EU-28 and has not increased much over time. In the EU, the share of these three high-skilled occupational groups increased from 38% in 2008 to 42% in 2018 in total employment, while in Turkey the share is much smaller and, in contrast to the EU, remained more or less stable over the same period (around 20%). The share of employment in elementary occupations is higher than in the EU and, again, has not changed over time (accounting for 14% of employment in 2008 and 2018). This non-increase of high-skilled occupations clearly has implications for stalling productivity in the economy.

Figure 3.3: Employment by occupation, 2008 and 2018



SOURCE: EUROSTAT – LABOUR FORCE SURVEY

Figures 3.4 and 3.5 show that the level of educational attainments in the EU are higher than in Turkey. If one looks at the percentage of people employed who possess a tertiary level qualification it is apparent that the gap between Turkey and the EU has remained constant over time. In 2006, the percentage of people in employment with tertiary level qualification in the EU was 26% and 14% in Turkey; a gap of 12 percentage points. By 2019, 36% were so qualified in the EU and 26% in Turkey; a gap of 10 percentage points. Most importantly, the share of the low-skilled still remains very large (53% in 2019) in Turkey as against 17% in the EU, while the medium-skilled is the smallest group (22%) as against the largest group in the EU (47%).

The above is very much about outputs from the initial education and training system. Participation in education and training in the last four weeks provides an indication of the extent to which people are engaged in continuing vocational education and training. As the Eurostat LFS reveals, adult participation in lifelong learning activities (aged 25-64) in Turkey (5.8%), though increasing over time, are much below the EU-28 average (11.2%)[17]. To some extent this reflects the relatively high shares

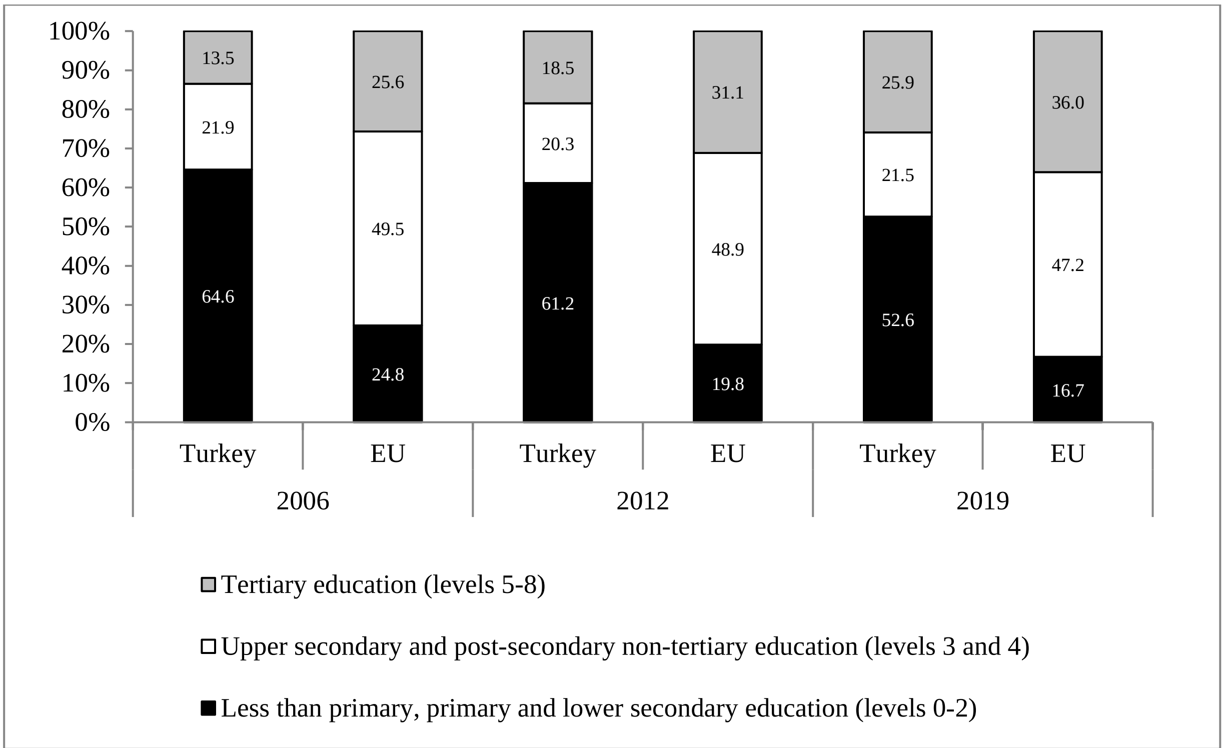
and 4) and the low-skilled (ISCED 0-2) – with specified qualification levels in brackets. On top of this, skills in 21st century give higher importance to individual reasoning, interpretation and application of knowledge and creativity, with special emphasis on core skills and soft skills (e.g. effective literacy and numeracy, digital skills, foreign languages, learning-to-learn skills, communication skills, problem-solving skills, creativity, personal effectiveness, etc.)

[17] Eurostat – Labour Force Survey

of people employed in relatively low-skilled employment. Results from PIAAC 2016 revealed Turkey showed below-average proficiency in literacy, numeracy and problem solving in technology-rich environments compared with adults in other OECD countries. In particular, only 8% of adults attained one of the two highest proficiency levels in problem solving in technology-rich environments, while 40% of adults reported no computer experience or failed the ICT core test. 18

And if one looks at levels of educational attainment in the population aged 15-64 years, one can gain a similar insight into skills supply (Figure 3.5). The evidence demonstrates that levels of educational attainment in Turkey are lower than those in the EU and the difference is more or less constant over time. In 2019, 61% of the Turkish population aged 15-64 years old were low-educated, 21% of them were medium-educated, and 18% were highly educated. The corresponding shares in the EU-28 were 25%, 46% and 30%. So the education gap between Turkey and the EU is not decreasing: whilst educational attainment has increased over the recent past in Turkey, they have also increased in the EU at more or less the same rate such that the attainment gap has remained more or less constant.

Figure 3.4: Levels of educational attainment amongst those aged 15-64 years in employment in Turkey and the EU



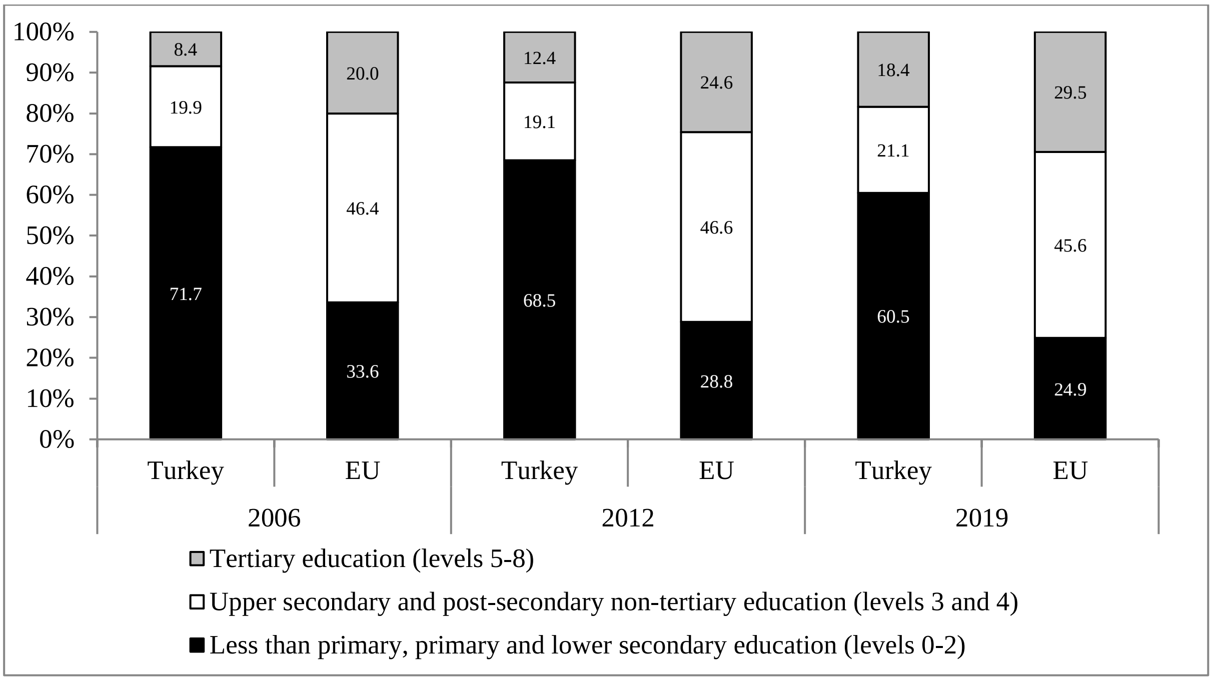
SOURCE: EUROSTAT – POPULATION BY EDUCATIONAL ATTAINMENT LEVEL [EDAT_LFS_9902]

The level of skill demand can be obtained from looking at the level of educational attainment of those in employment aged 15-64 years. Figure 3.4 shows that the level of educational attainment in the EU is higher than in Turkey. If one looks at the percentage of people employed who possess a tertiary level qualification it is apparent that the gap between Turkey and the EU has remained constant over time. In 2006, the percentage of people in employment with tertiary level qualification in the EU was 25.6% and 13.5% in Turkey; a gap of 12.1 percentage points. By 2019, 36% were so qualified in the

18 OECD, Skills matter: further results from the survey of adult skills. Country note Turkey, OECD Publishing, Paris, 2016. Available at: http://www.oecd.org/skills/piaac/Skills-Matter-Turkey.pdf

EU and 25.9% in Turkey; a gap of 10.1 percentage points. But the real gap is among the medium-level qualifications: while 47.2% of workers in the EU are medium-educated and only 16.7% low-educated in 2019, only 21.5% of Turkish workers are medium-educated and the majority (52.6%) are low-educated. Strangely enough, the share of medium-educated workers in Turkey never increased, on the contrary, there was a slight decrease from 21.9% in 2006 to 21.5% in 2019.

Figure 3.5: Levels of educational attainment in the population of 15-64 year olds in Turkey and the EU



SOURCE: EUROSTAT – POPULATION BY EDUCATIONAL ATTAINMENT LEVEL [EDAT_LFSE03]

Given the interest in the automotive sector, it is perhaps worth comparing the levels of educational attainment in those EU countries which have sizable automotive sectors such as Germany, Spain and Slovakia (see Table 3.1). Among those qualified at ISCED levels 3 and 4, the share of the population with this level of qualification is relatively low compared with the countries with relatively substantial automotive sectors except for Spain. Many automotive assembly line jobs typically require people to be educated to this level often through an apprenticeship (medium-skilled). The gap at the tertiary level is less large. So depending upon where future growth in employment takes place in the automotive sector, Turkey may be more or less disadvantaged with respect to meeting skills demand. As indicated in later sections – based on the big data analysis - there appears to be an increasing demand for people to work in grey-collar jobs or those sometimes referred to as technician level ones in other countries. It is likely that many of these jobs will require skills at least a level equivalent to ISCED levels 3 and 4 (and ISCED 5A). This potentially places an increased demand on the TVET system in Turkey given the relatively low percentage of people currently qualified to this level compared with other countries.

Table 3.1: Levels of educational attainment in the populations of Turkey and countries with large automotive sectors (Germany, Spain, and Slovakia), 2019

	Turkey	Germany	Spain	Slovakia
Less than primary, primary and lower secondary education (ISCED levels 0-2)	52.6	12.6	32.2	4.4
Upper secondary and post-secondary non-tertiary education (ISCDE levels 3 and 4)	21.5	57.7	24.0	68.3
Tertiary education (ISCED levels 5-8)	25.9	30.0	43.8	27.3

SOURCE: EUROSTAT – POPULATION BY EDUCATIONAL ATTAINMENT LEVEL [EDAT_LFSE03]

The evidence tends to point to Turkey being in low skills-equilibrium compared with the EU. The demand for higher skills is relatively low to which the skills system responds but, where skills supply has increased it is apparent that the labour market has struggled to absorb those skills resulting in skill mismatches. This seems to be essentially a problem of over-supply in certain skills.[19] There is also evidence of under-supply, based on data from the jobs portal ISKUR, several of the jobs where demand outstrips supply (where the growth in job vacancies has been greater than the growth in job placements) are of direct relevance to the automotive sector: CNC operators; sales consultants; electricians; and automotive assembly line workers. Those most demanded occupations tend to be mostly intermediate (medium-skilled) ones.

3.4. The automotive sector

Total employment figures in Turkey show that in 2018 services sector employed the largest share of people (55%), followed by industrial employment (27%) in the country, while the share of agricultural employment (18%) was also substantial. This section provides a description of output, employment, skills in the automotive sector. There is a need in the first instance to provide a definition of the sector. Using NACE as a guide, one can define the sector broadly to include both the manufacture and sale of vehicles as follows:[20]

28.3 Manufacture of agricultural and forestry machinery;[21]

29 Manufacture of motor vehicles, trailers and semi-trailers;

45 Wholesale and retail trade and repair of motor vehicles and motorcycles.

There are substantial differences in the use of technologies and skills in the manufacturing and service sectors respectively which needs to be borne in mind when contemplating the skill needs of the sector.

The automotive sector's development in Turkey

The first major automotive plant in Turkey was established in 1956 when Otosan was licensed to produce Ford vehicles. There are now 14 original equipment manufacturers (OEMs) in Turkey, with a

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19 World Bank, *Firm Productivity and Economic Growth in Turkey: Turkey Productivity Report 2019*, Washington, 2019.

20 The EU's Blueprint for Sectoral Co-Operation on Skills: Automotive includes both manufacturing and service sectors, but not agricultural machinery.

21 This will include tractors.

total output of around 1.5 million vehicles produced annually (2019).22,23 The output of the Turkish automotive industry is very much in line with other European countries with developed car manufacturing industries, such as Czech Republic and Slovakia. Respectively, these countries produced 1.4 million and 1.1 million vehicles in 2019.24 The majority of vehicles are produced in the north-west of Turkey in the regions of Kocaeli, Sakarya, and Bursa.25 Output growth in automotive, both in automotive manufacturing and sales, has outstripped that in the economy as a whole over the period 2009-2017. So it is an important driver of growth in the national economy.

In general, where employers are engaged in international markets – or are faced with international competition – it tends to drive up their skill demands where enterprises are trying to capture higher value segments of the global market.26 It is readily apparent that the Turkish automotive sector is one engaged in international trade and one which faces import competition. In 2019, the automotive sector exported around 80% of its total production (valued at $21 billion compared with $13.3 billion in 2013).27 Passenger cars are the major export (which accounted for 829 thousand units in 2019), though the number of total exports - and those of passenger cars in particular - has been slowly decreasing over recent years.28

Turkey is also a large importer of vehicles: in 2017 cars were the third largest category of all imports - after gold and refined petroleum – and accounted for 4.1% of all imported goods.29 As per capita income has increased, it has driven up the demand for cars from consumers; increasingly foreign produced ones. In 2014, 73% of all passenger cars sold in Turkey were imported (mainly models from Volkswagen, Opel and Ford).30 The key issue here is the product market trajectory of the sector in the future – i.e. whether, for instance, it increasingly shifts away from production and increasingly into design and manufacture.

The Covid-19 is a threat to the economy in general and to the sector. Research estimates that some 7 million workers are at risk of losing their jobs in Turkey due to economic consequences of the pandemic: the automotive sector shows both a high sectoral risk for negative economic effects (mostly due to plants being forced to close as non-essential sectors) as well as a high risk of employment vulnerability (due to many of the tasks linked to the production of vehicles not suitable for teleworking).31 To date, global forecasts indicate a 20% fall in sales (to level last seen during the 2008

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22 Original Equipment Manufacturers (OEM) are the manufacturers of the original vehicle equipment, that is, the parts assembled and installed during the construction of a new vehicle. In contrast, aftermarket parts are those made by companies other than the OEM, which might be installed as replacements after the car comes out of the factory. Generally, the distinction is not based on the quality and/or price of vehicle parts. The 14 OEMs in Turkey are: Anadolu Isuzu, Bozonkaya, BMC, Fiat, Ford Otosan, Honda Türkiye, Hyundai Assan, Karsan, M.A.N. Türkiye, Mercedes-Benz Türk, Otokar, Oyak Renault, Temsa, Tofaş, Toyota.Türk Traktör and Hattat Traktör are tractor manufacturers.

23 Annual report from the Automotive Manufacturers' Association (OSD), version 2020 (data updated at January 2020. Available at: http://www.osd.org.tr/sites/1/upload/files/YILLIK_2020-5479.pdf

24 Data from International Organisation of Motor Vehicles Manufacturers (OICA), available here: http://www.oica.net/category/production-statistics/2019-statistics/

25 http://osd.org.tr/Sites/1/upload/files/2018_YILLIK-3299.pdf#page=3

26 Mason, G. (2004) *Enterprise Product Strategies and Employer Demand for Skills in Britain: Evidence from the Employers Skill Survey*. SKOPE Research Paper No.50

27 http://osd.org.tr/Sites/1/upload/files/2018_YILLIK-3299.pdf#page=10

28 http://osd.org.tr/Sites/1/upload/files/2018_YILLIK-3299.pdf#page=3

29 https://oec.world/en/visualize/tree_map/hs92/import/tur/all/show/2017/

30 https://oxfordbusinessgroup.com/analysis/turkeys-automotive-sector-sees-increase-investment-output-and-exports

31 World Bank, "Jobs at risk in Turkey: Identifying the impact of COVID-19", Social Protection & Jobs Discussion paper n. 2004, July 2020. Authored by Sırma Demir Şeker, Efşan Nas Özen and Ayşenur Acar Erdoğan.

financial crisis), though the situation remains highly uncertain.32 The Transport Vehicles Supply Industry Association (TAYSAD) has indicated that Covid-19 could result in a $5 billion loss for the sector in Turkey. Some of this loss could be offset by increased demand for parts from Europe given the difficulties it has faced in sourcing parts from its main supplier - China.33 Nevertheless, Covid-19 poses a number of challenges for the automotive industry depending upon its wider impact on the global and Turkish economies and the resulting consumer demand for vehicles.

Employment and skills[34]

Employment has increased substantially over recent years in the sector. Over the period from 2009 to 2017 it has nearly doubled: from 387 thousand to 607 thousand – with almost 64% increase of employment in the sector. This means that approximately an additional 220 thousand people are employed in the sector since 2009 (219 481 persons to be precise) (Table 3.2). The 607 thousand people employed in the automotive sector represented 2% of total employment in 2017, and it did not necessarily include the sector's supply-chain in its entirety: these figures would have climbed to an estimated 1.25 million if these were included.35

Of the 607 thousand it is estimated that around 50 000 people were employed in OEMs in 2019; an increase from the 42 000 employees in 2013.36 Table 3.1 shows the scale of change to reveal that much of the growth has been accounted for by an increase in the number of people employed in the wholesale and retail trade of passenger vehicles, though there has also been a substantial increase in passenger vehicles too. These trends may well reflect increasing domestic demand for vehicles over time.

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32 https://www.economist.com/briefing/2020/04/25/the-worlds-car-giants-need-to-move-fast-and-break-things

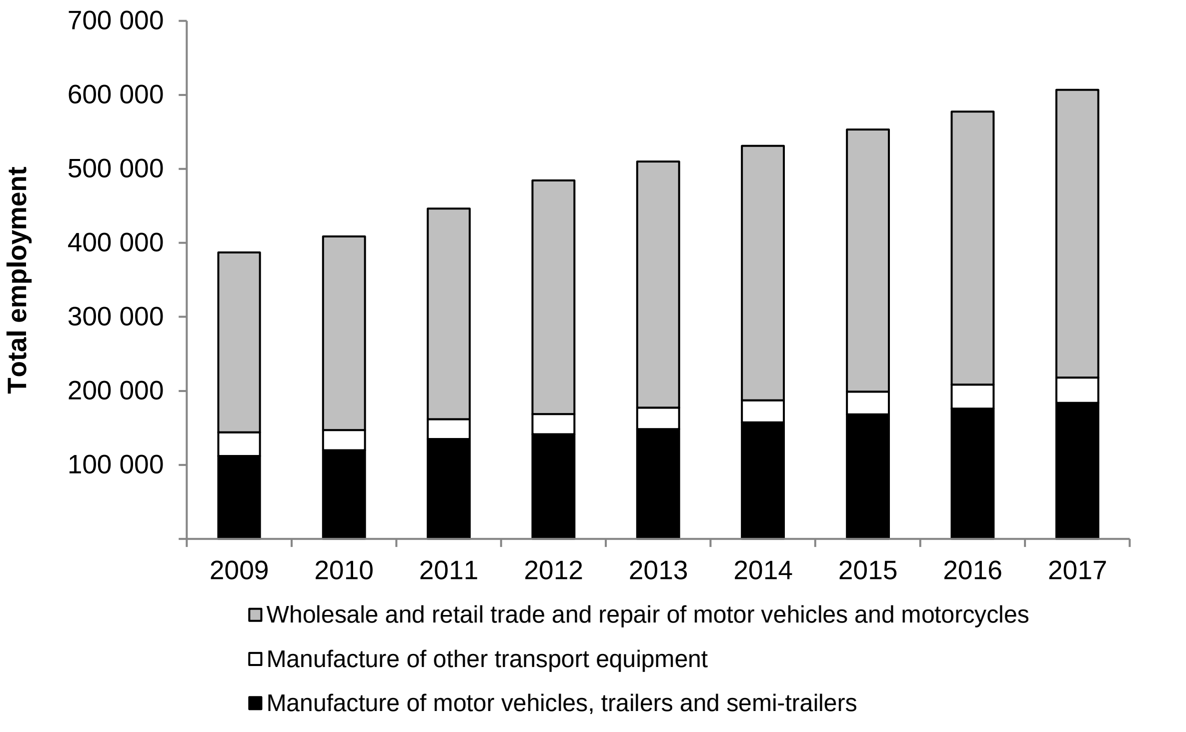
33 https://www.hurriyetdailynews.com/limited-pandemic-impact-on-turkeys-automotive-sector-expected-trade-group-154245

34 As mentioned before, the education levels of people are used as proxy for their skills levels in this analysis, such as the high-skilled (ISCED 5 and above), the medium-skilled (ISCED 3 and 4) and the low-skilled (ISCED 0-2) – with specified qualification levels in brackets. On top of this, skills in 21st century give higher importance to individual reasoning, interpretation and application of knowledge and creativity, with special emphasis on core skills and soft skills (e.g. effective literacy and numeracy, digital skills, foreign languages, learning-to-learn skills, communication skills, problem-solving skills, creativity, personal effectiveness, etc.)

35 TAYSAD, "The pursue of perfection! Meet the Turkish Automotive Suppliers' R&D and Design Centres", online document: https://www.taysad.org.tr/uploads/TAYSAD-AR-GE-Grubu-Kitap-OK.pdf

36 https://oxfordbusinessgroup.com/analysis/turkeys-automotive-sector-sees-increase-investment-output-and-exports

Figure 3.1: Change in automotive employment, 2009 to 2017



SOURCE: TURKSTAT NATIONAL ACCOUNTS DATA

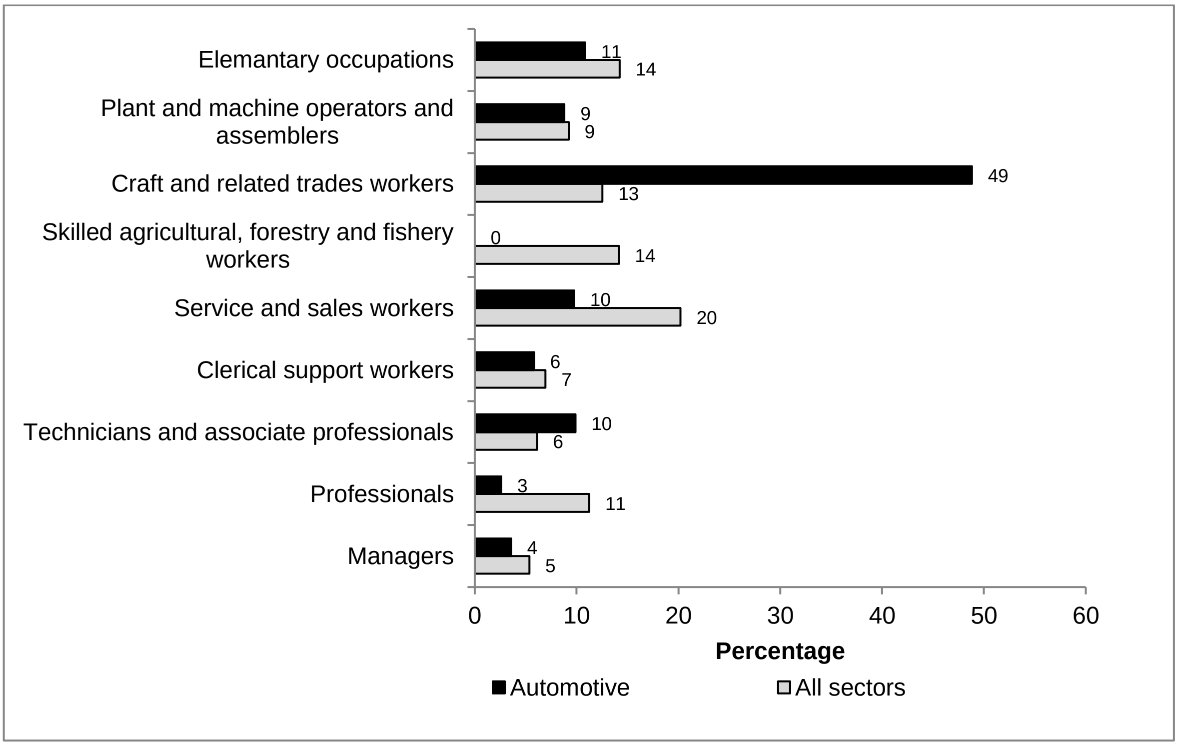
Table 3.2: Employment change in the automotive sector 2009-2017

	Absolute change in units 2009-2017	Percentage change	Annual average percentage change
Automotive ***of which…***	**219 481**	**57**	**+6.6**
Manufacture of motor vehicles, trailers and semi-trailers	72 045	64	+7.4
Manufacture of other transport equipment	2 176	7	+0.9
Wholesale and retail trade and repair of motor vehicles and motorcycles	145 260	60	+6.9
All sectors included	**5 907 047**	**58**	**6.8**

SOURCE: TURKSTAT NATIONAL ACCOUNTS DATA

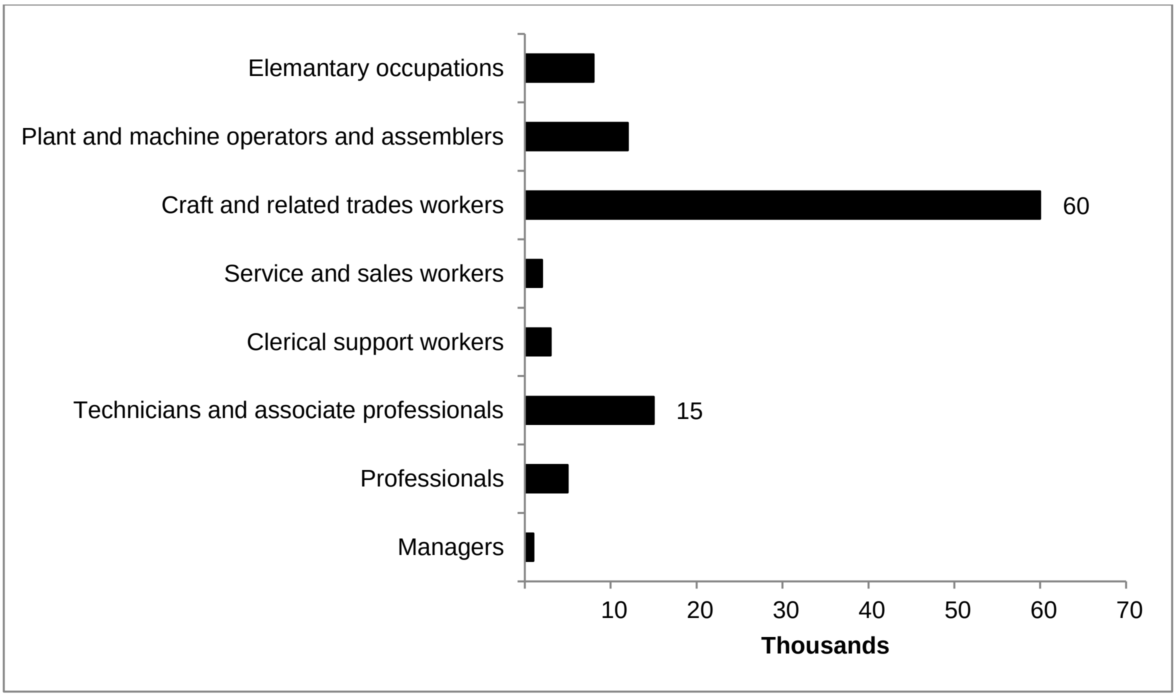
One can obtain an indication of skill levels from looking at the occupational distribution of employment in the automotive sector (as defined above) and the educational level of people employed in the sector. Figure 3.3 compares the occupational structure of employment in the economy overall with that in automotive in 2019. It reveals that the automotive sector is relatively more dependent upon (a) technicians and associate professionals (10% in automotive against 6% in total) and (b) craft and related workers (49% in automotive against 13% in total) compared with the economy as a whole. Interestingly, the percentage of people employed in managerial, professional, associate professional occupations – so-called higher-level occupations – is at 17% in the automotive sector, slightly lower than the economy as a whole at 21%. Between 2014 and 2019 the occupational structure has not changed much, but given that the number of people in the sector has been increasing, this has resulted in a relatively strong inflow of people into craft and related trades workers, and into technician and associate professional jobs (see Figure 3.4).

Figure 3.3: Occupational distribution of employment in Turkey, 2019



Source: Turkstat Labour Force Survey

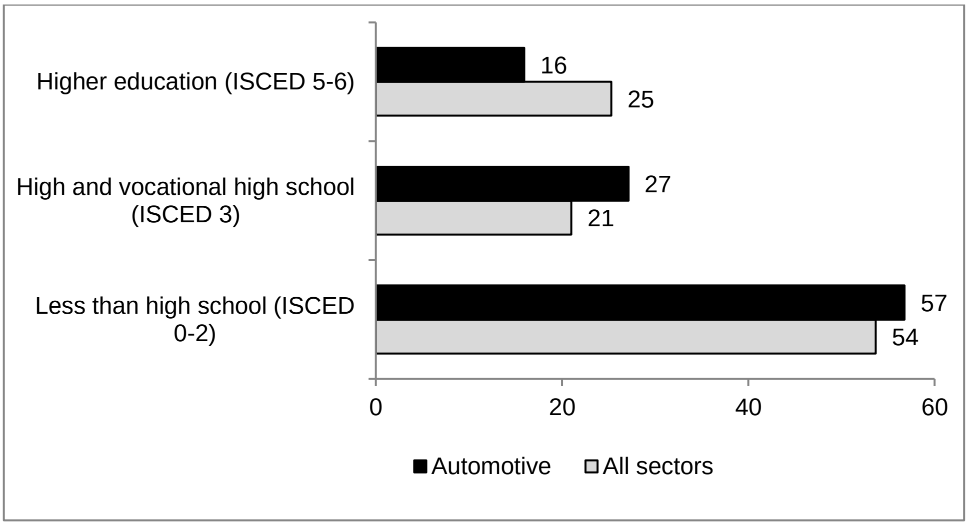
Figure 3.4: Change in employment in the automotive sector 2014-2019



Source: Turkstat Labour Force Survey

A further insight into skill demand in automotive can be gained from looking at the education level of those working in the automotive sector (see Figure 3.5). This shows that the education level of those working in the automotive sector is similar to that found in the economy as a whole: 57% low-skilled, 27% medium-skilled, and 16% high-skilled. The difference in the automotive is a slightly higher dependence upon those educated at ISCED level 3 and a slightly lower one on those at tertiary educated level (Figure 3.5).

Figure 3.5: Qualifications held by the workforce in the automotive sector, 2019



Source: Turkstat Labour Force Survey

In relation to the automotive sector, the data indicate that the sector is relatively dependent upon a level and type of skill that is typically provided via vocational education in the EU. Craft and related workers working in the manufacturing sector have typically completed technical/vocational education and training (or apprenticeship) usually at ISCED level 3 or 4. But in Turkey, 57% of employed in the automotive sector are low-skilled with basic education (ISCED levels 0 to 2). This is quite atypical compared to the EU, but the increasing share of medium-skilled workers in the sector (27%) points to the future of the automotive sector being increasingly dependent upon the capacity of Turkey's VET system.

Innovation, technological change, and skills

The future direction of the automotive sector across the world will be determined by the shift towards electric vehicles and the use of autonomous systems (e.g. the degree to which driving a vehicle is controlled by various systems). These changes in design will affect production processes. Automation will also affect the future demand for skills in the automotive sector, though automation and robotics are already routinely used in production processes. According to two thirds of Turkish senior executives and labour unions representatives interviewed in the framework of a similar study, automation is expected to unlock significant potential for increased productivity growth and make the national economy more competitive.[37]

[37] Interviews were carried out by the Turkish Confederation of Employer Associations (TİSK) and involved 150 senior executives and labour union representatives. The study is quoted in McKinsey & Company Turkey in cooperation with the McKinsey Global Institute "Future of Work: Turkey's Talent Transformation in the Digital Era", January 2020.

Looking at the Turkish economy in general (so not just to the automotive sector, the McKinsey 2020 study concluded that by 2030, with the impact of automation and digitalisation, 7.6 million jobs could be lost, and 8.9 million new jobs could be created, a net gain of 1.3 million jobs. In addition, 1.8 million jobs that currently do not exist could be created, many of them in technology-related sectors. To enable this change, 21.1 million people in the Turkish workforce will need to improve their skills by leveraging technology while remaining employed in their current jobs. Automation and digitalisation are expected to affect 7.6 million employees through significant reskilling and job displacements. In addition, 7.7 million new employees who will join the workforce will need to be equipped with the latest skills required.**38**

The TISK study (together with TAYSAD and OSD) 'Digital Transformation in Automotive Industry' in May 2020**39** points to a number of emerging skills needs in the automotive sector. It notes that the production of electric vehicles is not the only concern of the automotive industry in Turkey. In fact, the digital transformation of industry is one of the most important current issues in Turkey. The state has established the model factories to serve industry through training for lean manufacturing and has provided funds to establish Digital Transformation (Innovation) Centres. The key basic digital transformation technologies include:

- Artificial Intelligence
- Big Data Analytics
- Intelligent(Smart) Robots
- Smart Systems
- Internet of Things
- Cloud Computing
- Cyber Security
- Horizontal/Vertical Software Integration
- Sensors
- Image Processing
- Additive Manufacturing
- Virtual/Augmented Reality (VR/AR)
- Simulation

In the future it is likely that the automotive industry will increasingly require human resources competent in the use of these technologies. Different levels of training and education will be required for white- grey- and blue-collar workers.

In general, in the Turkish automotive sector, technological changes associated with Industry 4.0 and the like are seen to pose a threat to jobs in the middle of the occupational hierarchy, such as the craft and related trades jobs which are so common the Turkish automotive industry. In Turkey, however, the evidence suggests that the jobs at risk are, amongst others: technicians and associate professionals, sales workers, and plant and machine operators and assemblers.40 These are all jobs which are commonly found in the automotive sector. Craft and related trades workers are not seen as being particularly at risk.

The study from McKinsey reports that even though automation potential for work activities is considerable, just 2% of all occupations in Turkey are completely automatable, while 60% of jobs have

[38] McKinsey & Company Turkey in cooperation with the McKinsey Global Institute "Future of Work: Turkey's Talent Transformation in the Digital Era", January 2020.

[39] TISK Study (together with TAYSAD and OSD), "Digital transformation in automotive industry studied with suppliers and OEMs", May 2020.

[40] Sumer, B. (2018) 'Impact of Industry 4.0 on Occupation and Employment in Turkey' *European Scientific Journal*, Vol.14. No.10

at least 30% automatable activities – generally speaking, those jobs including elements of repetitive work. As noted by McKinsey, manufacturing (including automotive) is the sector with the most automatable activities: 12% of assembly line workers and machine operators have a share of 90% or more of automatable activities in their work, while 20% of the working time of manufacturing workers and machine operators is spent on activities with a 75% of automation potential.[41]

In this framework, the automotive industry is setting an example of growth not only from investing in manufacturing, but also from supporting the design and engineering perspectives. As a result of this, R&D and design expenditures, infrastructure and workforce in the industry are being supported and promoted by the government with different funds, enabling automotive companies to develop cutting-edge technologies. One of the most important actors in this field is TAYSAD, the Association of Automotive Suppliers of Turkey. With a total of 155 R&D and Design Centers, TAYSAD represents 17% of all R&D and Design Centers in Turkey. All these R&D and Design Centers have developed a number national and international funded R&D and Design projects on themes linked to the automotive industry, offering crucial engineering and manufacturing expertise in different fields.[42]

To date Turkey has responded to the challenges posed by technological change through, for example, the Turkish Vocational Qualification Agency's (VQA) occupational mapping of emerging skill needs and how the education system needs to respond (e.g. with respect to curricula). In the areas of autonomous systems, IT systems, artificial intelligence, digital industry, and advanced manufacturing occupational standards have been produced (e.g. for robotic systems operators). More specifically, the VQA working with Ford Otosan İhsaniye Automotive Vocational School has been preparing occupational standards in the field of industrial robot programming.[43] And in Kocaeli - one of the regions where the automotive sector is concentrated – plans are in place to support the introduction of technologically advanced production processes. Kocaeli University, for example, offers training in programming industrial robots typically used automotive and tailors courses to the needs of local industry.[44]

3.5. Conclusion

The automotive sector has been, and continues to be, an important element of the Turkish economy. It is an important source of output and export growth and is an important source of relatively high skilled employment (notably skilled manual work). Looking to the future it is likely that technological change in the form of automation, AI, robotics and so forth will play an important role in shaping skill demands. To date, the evidence demonstrates that much employment in the sector is concentrated in craft and related trades occupations (essentially skilled manual work), that comprise a number of activities with high potential of automation. In this case, many workers dealing with automatede activities will see their jobs and tasks reshaped by the adoption of automation, and will need to improve their skills or be reskilled to still be competitive in the labour market and make the best use of their expertise.

Compared with countries with substantial automotive sectors – such as Germany and Slovakia – Turkey has much fewer medium-skilled people qualified at ISCED levels 3 or 4 (the level often associated with craft and related trades jobs). Therefore, skilled manual workers in Turkey have – in

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[41] McKinsey & Company Turkey in cooperation with the McKinsey Global Institute "Future of Work: Turkey's Talent Transformation in the Digital Era", January 2020.

[42] TAYSAD, "The pursue of perfection! Meet the Turkish Automotive Suppliers' R&D and Design Centres", online document: https://www.taysad.org.tr/uploads/TAYSAD-AR-GE-Grubu-Kitap-OK.pdf

[43] Esma Doğan, "*Activities Carried Out by The VQA In the Field Of Industry 4.0*", presentation delivered in 2019.

[44] OECD (2017), Employment and Skills Strategies in Turkey, OECD Reviews on Local Job Creation, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264279506-en

general – lower level of schooling (less than upper secondary education), which makes further learning more difficult. This suggests, other things being equal, the skills system is relatively less well positioned to serve the needs of the automotive sector than in those other countries.

In the later sections, which report on emerging skill needs based on the big data analysis, evidence is provided of an increased demand for people to work in grey-collar occupations. These tend to be jobs which straddle the division between craft and related trades jobs and associate professional ones. In some countries they are referred to as technician level jobs. One would typically expect people to be qualified or skilled to a level equivalent to at least ISCED levels 3 or 4 (and even ISCED 5A) in order to fill these jobs. But as indicated in the commentary above, compared with other countries in Europe with a large automotive sector, relatively few people are qualified to this level of schooling in Turkey. This potentially poses a major challenge to the vocational education and training system – i.e. how can it increase the percentage of the workforce skilled and qualified to this level?

MAIN FINDINGS OF THE SECTION

- Many people employed in the automotive sector have low levels of educational attainment (less than 8 years of schooling), although they are extensively trained on-the-job by employers and sector associations. Low education level of workers may be a disadvantage in terms of having functional core skills and soft skills, also with implications on the effectiveness and cost of trainings provided by employers – given that the higher is level of schooling, the easier is new learning. This poses a risk of being one of the bottlenecks in the sector as well as for the economy in general.
- Employment in the sector is heavily dependent upon blue-collar manual workers with lower level of schooling in turkey, which means that the production processes in the sector can absorb those people. Other countries with substantial automotive sectors have education systems which produce many more qualified people at the medium level required to fill these types of jobs. This difference could be explained by the innovation capacity of those countries in production processes and higher productivity in their business structures.
- Technological change may transform the demand for skill – shifting from blue to 'grey collar' jobs in Turkey – as it happened in other countries. Grey-collar refers to the employed people not classified as white- or blue color, in those occupations that incorporate some of the elements of both blue- and white-collar, and generally are in between the two categories in terms of income-earning capability.[45]

[45] For the information of general readers, grey-collar workers often have licenses, associate degrees or diplomas from a trade or technical school in a particular field. They are unlike blue-collar workers in which they can often be trained on the job within several weeks whereas grey-collar workers already have a specific skill set and require more specialized knowledge than their blue-collar counterparts. Examples include pilot and flight attendants, paralegals, technicians, firefighters, polic officers, emergency medical service personnel, chefs, childcare workers, non-physician health care workers, etc..

4. KEY DRIVERS OF CHANGE in the SECTOR

KEY ISSUES COVERED BY THIS SECTION

- Analysis of the main drivers of change currently shaping the sector (e.g. global value chains, new technologies, digital tools, international regulations…).

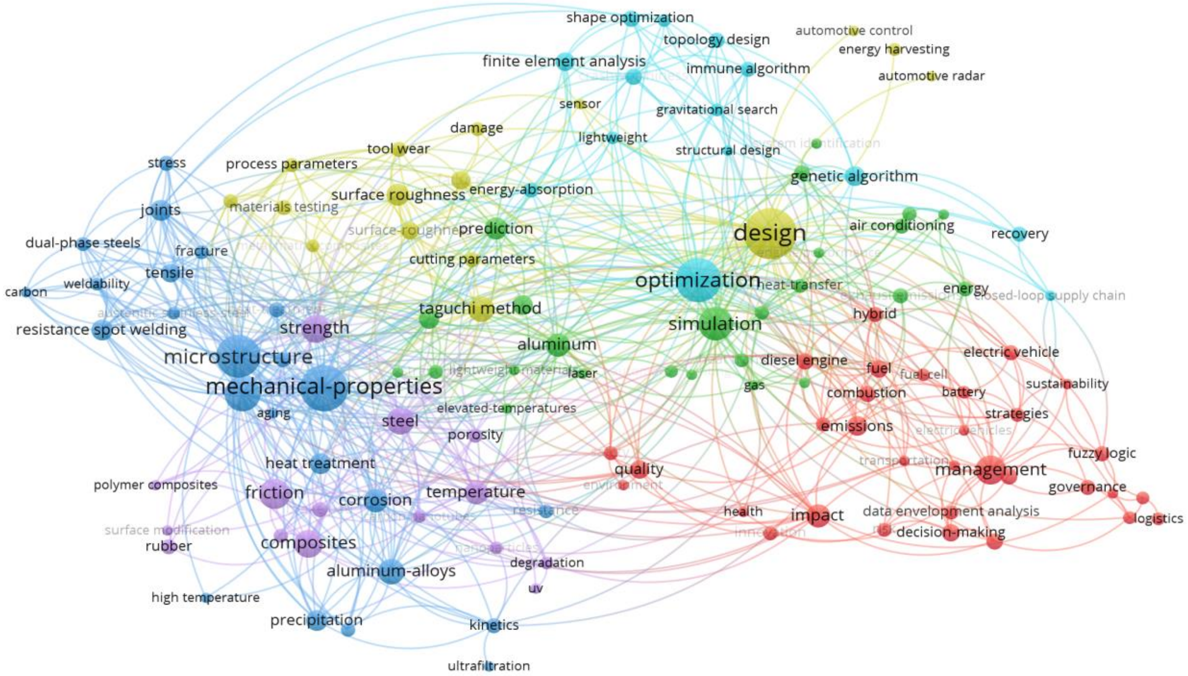
The preceding chapter has outlined the broad contours of skill demand in the automotive sector. In moving towards a more detailed analysis of skill needs – i.e. what are the actual skills people use in their jobs and how are they likely to change? – there is a need to understand the factors which are driving the change and those technologies that are associated with that change. It is not just about technological change: a need to consider a variety of non-technological factors which will shape the future is relevant as well. In the sections below, consideration is given to the range of technological and non-technological factors driving the change in the automotive sector in Turkey.

4.1 Identifying drivers of demand

Fast technological development is a major factor influencing the demand for skills. But technology does not account for everything. There are many other factors such as social, economic, and environmental ones which shape future skill needs. In order to study all the possible drivers of change, the entire Scopus and Web of Science databases have been searched to find scientific papers and conference proceedings related to the automotive sector in Turkey. In addition, websites have been scraped for direct information and access to various studies. The documents gathered have been scanned with text mining tools to extract the most relevant keywords which are then clustered by using network analysis.

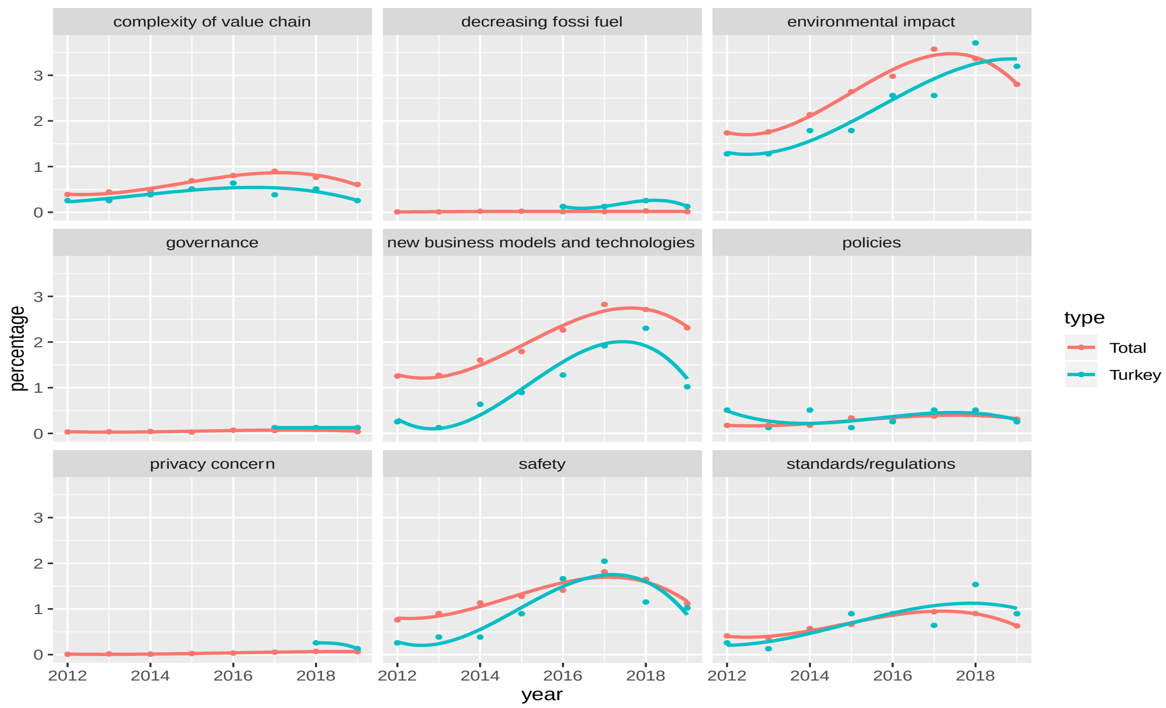
Figure 9 provides a snapshot of such a clustering process: for example, the red group of connected terms clearly points to the semantic area of emissions reduction. Browsing the network of correlations between the topics provides an understanding of the relationships between them. For instance, attention to reduction of emissions could turn into consideration towards electric vehicles, which then leads to new design solutions, vehicle optimisation and programs for simulation (yellow, light blue and green clusters respectively). The inspection of all clusters provides the basis for identifying potential candidates for drivers of change.

Figure 9: Network diagram of keywords related to the automotive sector in Turkey from the analysis of scientific papers



A driver of change is considered to be a factor that strongly influences the evolution of future scenarios. By combining the clustering with an analysis of change over time (i.e. the number of scientific papers each year) it is possible to identify if one is observing phenomena which are increasing (see figure 10 for examples).

Figure 10: Distribution over the years of key concepts identified from the analysis of scientific papers on automotive



From the text mining described above, a series of non-technological drivers of change were identified. Each of those is able to bring some changes to the sector and, in turn, may cause new skills to be needed and recruited by the companies and, in some cases, new profiles to be created for the sector.

The results obtained have been validated and supplemented by the interviews with both stakeholders and companies during the field missions. This led to the identification of two additional drivers of change not captured by the text mining: the "increasing customers' expectation and customisations of products" and the "economic and political instability". Moreover, the cluster of "design" has been better contextualised in terms of the Turkish companies' strategy to upsell along the value chain. In this regard it is possible to understand that the greater focus on design is to be understood from an engineering point of view rather than an aesthetic one. Thanks to the engineering skills and competences developed in recent decades, many Turkish companies can nowadays develop the product design process entirely within their organisation, evolving from a mere supplier role to a co-designer or in some cases to a designer one, producing original innovative products. This change leads to a dramatic upgrade of their position in the automotive value chain. For some companies, this evolutionary process is not a strategy for the future but it has already happened, while for others it is underway. Here all principal drivers of change are described, and in the next subsection the technological ones will be further elaborated.

Introduction of new technologies

The introduction of new technologies is considered by many stakeholders and companies to be the most relevant driver of change for the sector. The shift to new types of vehicles, in particular electric/hybrid cars and smart/autonomous vehicles, is surely re-shaping the focus of Turkish companies. The research of new materials, often in relation to electric mobility (e.g. lightweight components, new batteries, etc.), also has an important impact, per se and because of the need for new tools and machines to deal with them. At the same time, new production paradigms such as "smart factories" and Industry 4.0, or the spread of robots and automation (which, as interviews confirmed, received a boost in recent years), down to software to manage the supply chain (e.g. ERP software), are radically changing the internal processes and organisation. Clearly, digitalisation and smart factory systems translate into new skill requirements and, potentially, the emergence of new job profiles[46], as these paradigms introduce new concepts and roles for the workforce in the production process. Furthermore, technological progress is also related to other drivers of change. For instance, driver assistance systems (DAS) have been introduced to minimise human error and thus reduce road fatalities (cfr. the driver "increasing concern and attention given to safety issues"). In fact, the need to introduce new technologies is strictly connected to the competitive scenario: interviewees stated that companies that will not innovate and adapt would be cut off from the global value chains and will likely not survive in the market.

Emergence of new business models

The sector is also experiencing the emergence of new business models, either in response to changes in people's mobility habits or enabled by the technological input. For example, online trading will reshape the chain of distribution and the number of people between the company and the final retailer will be reduced or even eliminated. The business model will also change: due to the general worldwide trend in mobility behaviour for renting or sharing cars instead of owning them, manufacturers will have to find new ways of creating value, for example offering more services, and even more so when self-driving cars will be reliable enough for vehicle fleets to be always available to everyone. The availability of 3-D printing techniques for rapid manufacturing also plays a relevant role since it leads to a reduction

[46] Jerman A., Pejic Bach M., Aleksic A., Transformation towards smart factory system: Examining new job profiles and competencies, https://doi.org/10.1002/sres.2657

of costs of production for certain parts, but it also enables prototypes to be easily moved within the supply chain.

Integration with Global Value Chains

The growing role of global value chains (GVCs) in international production processes is of critical importance for Turkey's development. Participation in GVCs is one of the key drivers of successful productivity diffusion in a globalised world, and after all 72% of Turkish automotive production is destined to export, often to feed the supply chain of international OEMs. Benefits are not only economical but related for example to positive technological spill overs towards other sectors and the acquisition of important knowhow and best practices. Yet, deepening integration in GVCs exposes countries to a greater number of shocks although a better regional and product-range diversification can offset the adverse effects on stability.

According to an OECD study, "Turkey's participation in global value chains remains below potential owing to institutional features that hamper efficient allocation of capital and labour, obstacles inherent in bilateral trade agreements and entry regulations, underdeveloped human capital and insufficient investment in innovation"[47]. However, various positive trends are taking place. Since 2000, many Turkish companies have been undergoing functional upgrading, moving from mere assembly or licensed low-end production to producing original higher-added-value parts, deepening their GVC integration and moving towards its higher-end. National global players, such as for example TOGG, are also starting to appear. A competitive advantage of Turkey with respect to GVCs is its geographical proximity with Europe, a factor that may become even more important because of changing trends in international trade, leading to a replacement of Far East products, and the Covid-19 pandemic is going to accelerate this trend.

Complexity of the Value Chain and increased relevance of Logistics

Logistics is a central component of the whole value chain of the automotive sector. Such prominence is surely driven by globalisation but also by the changing attitudes of customers who demand for higher product variety. Due to the sheer scale of goods movements implied, the logistical chain is also clearly related to environmental impact. The complexity of the product, in terms of the number of subassemblies, and the high requirements in quality standards lead the companies to efficiently coordinate their actions to supply the carmaker with the necessary parts and components. Moreover, most of the problems the companies have faced during the Covid-19 pandemic are related to the difficulties in importing raw materials and components from abroad. As a consequence, smarter management of the value chain is expected to become even more important. In the future, for some kind of commercial activities (e.g. aftermarket or OEMs), it is expected that the online trading will reshape the chain of distribution and the number of actors along the chain will be reduced.

International competition

The strong international competition, for example from BRIC countries, is a very important driver, also because of the low profit margins of the sector (4% in best cases) that guide many strategic choices. The competition on suppliers to get lower prices is continuous. This leads to adopting new production processes and techniques to increase optimisation and efficiency and reduce costs, such as lean management, smart factory solutions, simulation and modelling software, additive manufacturing, and in recent times increasing investments in robots and automation. Additionally, some disruptive competitors belonging to different sectors, such as Panasonic, but also Google and Apple, have

[47] https://www.oecd.org/eco/Reaping-the-benefit-%20of-global-value-chains-in-Turkey.pdf

entered the market with electrical car or autonomous driving car solutions. Since even key players will change, the ability to adapt is critical for surviving.

Increasing customers' expectation and customisation of products

As both the desk research and the interviews pointed out, the changing attitude of the customers is a critical factor. Consumers' expectations are high and varied, so companies must work on differentiation of products and customer satisfaction more than ever. Costs and quality of products also need to be kept adequate to the customers' demand. This contributes to increasing the level of competitiveness within the sector, but also to creating the opportunity for companies for reviewing and improving processes by introducing innovative solutions. Indeed, to manage customisation, digitalisation is a necessary solution, as is developing design and R&D capabilities.

The following three topics, Governance, Design and Quality, are not drivers of change *per se*, but have emerged from the data analysis as important factors behind companies' strategies and are strongly correlated to the drivers discussed so far.

Governance. This is a central concept in the automotive industry, connected with the high complexity of the value chain. Humphrey and Schmitz[48] suggest that without the notion of governance, the value chain would "just be a string of market relations". In an evolving and highly competitive sector, the commitment to careful governance is critical for success on the market. For example, in Turkey, various companies are led to join efforts to share the high costs of digitalisation or automation.

Design. In the past, the Turkish car industry was merely assembling cars or producing components on international OEMs request. Over the years, Turkish companies managed a successful functional upgrade, starting to produce new, higher-value, proprietary car components which are now exported to the entire world. Many of the interviewed companies stressed how their ability to design new products (from innovative components for electrical cars to sensors embedded in plastic parts) constitutes a major factor in their success and a decisive advantage over competitors focusing only on reducing prices. This factor in turn has great implications in terms of workforce, since companies are setting up entire R&D and testing departments, requiring a variety of advanced skills.

Quality. Both competition and customer expectations exacerbate the need for quality in production, because the actual market does not accept delays and issues of low quality. Improvements need to be made directly on the production lines: visual control by cameras, artificial intelligence for item control, optical scanners for measurements. In turn this will affect the skills of the employee, not just for the blue collar but for engineers and white collars as well.

Economic and political (in)stability

Over the last 30 years, Turkey has experienced recurrent periods of instability, coupled with high inflation and volatile currency. This has various types of impact on the sector: the possible withdrawal of foreign investments (which have to be substituted with national investments); fluctuation of market prices and conditions, especially affecting the domestic market; the existence of trade barriers, import/export taxes; higher costs of international loans for the sector investments; due to changing political conditions.

Public policies and incentives

The development of the car industry has always been related to government's policy decisions about infrastructure, urban development and so on, and the fostering of a healthy national automotive sector requires government policies at both the macroeconomic and the microeconomic level for promoting

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48 Humphrey, J. and Schmitz, H. (2001) Governance in Global Value Chains. IDS Bulletin 32(3): 19-29

the development of production and sales. A recent example is the Government effort to support brands for realising electric vehicles in the country and enhancing the national competitive advantage with respect to the electric revolution. Another supporting measure is the successful attempt to boost innovation by stimulating patent filing and protection. The Scientific and Technological Research Council of Turkey (TÜBITAK) has launched the Support Programme for Research, Technological Development and Innovation Projects in Priority Areas (TÜBİTAK-1003), with automotive as a main target. Incentive and tax policies are also relevant; in Turkey there is a huge taxation for buying new cars that leads consequentially to a reduction of the internal market size.

Standards and regulations

Recent decades have seen the introduction of numerous standards and regulations, in terms of quality, performance and safety, which influenced the car industry. The adoption of technologies is not only made possible by recent advances of software, hardware, and communication systems, but is often prompted by the introduction of various applications and regulations, in particular those concerned with environmental standards.

Safety requirements

Automotive industry has always been highly focused on safety issues, from braking systems to protection of passengers. In the present day there is a renewed emphasis on this aspect, in relation to autonomous cars; alongside the obvious avoidance of crashes, there is also the need to overcome customers' concerns about the reliability of the technology. Indeed, due to high-profile crashes involving autonomous test vehicles in U.S., nearly three in four people in the country (71%) are afraid of fully self-driving cars[49]. Therefore, companies in the automotive industry are working to ensure safety, for instance by developing specific platforms which mitigate the threats of the untrusted code used to drive the car, or by implementing new collision avoidance systems.

Environmental Impact

The automotive industry and its products have a relevant impact on environment. Both the consumer demand and public actions (policy decisions, regulations/standards, and climate goals) are leading the automotive industry to find viable technological alternatives to reduce the negative effect of car pollution. The rise of hybrid/electrical cars is clearly prompted by the need to reduce CO_2 and other emissions, but the entire industry is called to a more sustainable production; for example, circular economy strategies and the adoption of recyclable materials (and even the use of recycled components) are also key drivers for the sector and enhance its value proposition.

Privacy Concern

In the era of intelligent transportation systems (ITS), vehicle-to-infrastructure communication (V2I), and data sent to roadside units (RSUs), the leak of sensitive information of the vehicle such as driving patterns and history, which may seriously violate privacy requirements[50], is becoming a relevant aspect for consumers. In this regard, various companies are developing systems for managing privacy issues.

Decreasing Fossil Fuels

The growth of interest in various alternative technologies such as hybrid or electrical vehicles is also the result of the recurrent crises in the oil market and the decreasing stocks of fossil fuels. It is believed

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[49] https://www.forbes.com/sites/tanyamohn/2019/03/28/most-americans-still-afraid-to-ride-in-self-driving-cars/#2c2579dd32da

[50] https://ieeexplore.ieee.org/document/8756293

that peak oil production has already been reached and has now entered a phase of decline as fossil fuel reserves become harder to locate.

Preliminary findings about the impact of Covid-19

Big data analysis has been conducted before Covid-19 reached Turkey and therefore cannot shed light on its consequences. Yet, interviews with companies allow few interesting considerations. For sure the pandemic created various problems to companies in the short term. Among those:

- delays in delivery due to suspension of work, that could compromise the relationship with costumers;
- cancellation of orders, which in turn led to liquidity shortage and decreased turnover;
- difficulties in importing raw materials and components from other countries;
- interruption of some business functions (such as sales) requiring face-to-face interactions.

However, during the lockdown period, employment has been preserved thanks to governmental support, and many of the interviewees expect the situation to go back to normality relatively soon. Actually, there is the chance that the current crisis will even lead to increased opportunities for the sector in the long term.

First, while customers may be reluctant to spend money on new cars, they will stop taking public transportation because of infection risks, turning again towards private cars, thus the overall balance could even be positive. Moreover, customers will always need spare parts for the existing vehicles (aftermarket).

Second, and more importantly, to overcome consumer reluctance about purchases that involve a greater commitment, new business models, such as rentals and leasing, will further emerge and develop, creating new opportunities[51]. In the same way an increase of demand is expected due to the response to the new challenges and the rise of new actors (such as TOGG in Turkey) in the automotive industry.

Third, Covid-19 highlighted the fragility of over-stretched and not diversified supply chains, and will lead to a return to localisation of production, or at least to more emphasis on the geographical proximity in supply and demand chains with consequences both on local investments and global trade. Local-to-local supply chains will provide more flexibility and the incremental costs of redundant sourcing outweigh the hazards of sole sourcing. In fact, investments in the Far East were already decreasing, being not as competitive as before, especially for foreign investors, and the pandemic only made it worse. This creates an opportunity for Turkey, because of its competence in the automotive manufacturing and its close position to the major European GVC and consumer market (which is already one of the main competitive advantages of Turkish manufacturing).

Finally, the crisis could boost technical innovation. Companies will increasingly adopt digital and analytical tools as they recognise the real value of predictive monitoring and supply/demand matching. Moreover, before Covid-19, automation was slow to be implemented because of long ROI times and low wages, now the investment in robots will be more attractive to contrast the negative effects of future pandemics.

4.2 The role of innovation

The discussion below is about technology as a driver of change. It is important to remark that the focus is not about technology *per se* but about its potential to influence, through its adoption, the demand for employment and skills. From a methodological point of view, the interest is in the ***functional use of***

[51] https://www.mckinsey.com/industries/advanced-electronics/our-insights/coronavirus-five-strategies-for-industrial-and-automotive-companies

technology rather than on its performance or actual content. Every technology exists to fulfil a purpose for the user, to solve a real-life problem, or provide an advantage. In the theory of engineering design, the purpose is referred to as the *function* of the technology.

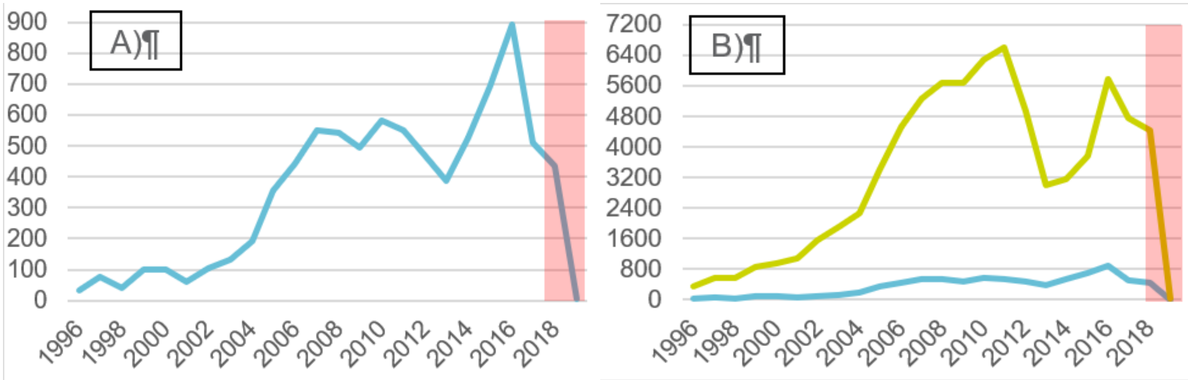
The current literature on the future of work and skills focuses more on the potential of new technologies, but existing empirical evidence is very limited on the actual impact of technology use in companies. By looking at the functional use of the technology – i.e. the actual problem it solves or the actual beneficial uses it enables – it is possible to study its real impact in the real world. Moreover, even if a specific technology is not eventually adopted, if the need expressed by its functional use is real, in the long term another substitute technology will appear. In this sense, the functional approach allows for an understanding of the obsolescence and/or resilience of certain jobs or occupations and forecasting or even designing the shifts occurring between jobs, and the trajectory of skills from one job to another.

The first analysis is a general one and concerns the competitive potential provided by technological development. One indicator of the innovative capacity of a country is given by its capability to invent, expressed by the patents filed by companies and research centres. Of course, not only quantity but also quality is important, yet even the sheer number of patents provides a useful measure of innovation.

Figure 11A shows the patents filed over the years in the automotive sector in Turkey, whereas Figure 11B compares the latter with the total number of filed patents in Turkey. Figure 12 compares the number of automotive patents filed in Turkey versus the total number of patents worldwide related to the automotive sector, expressed as a percentage.

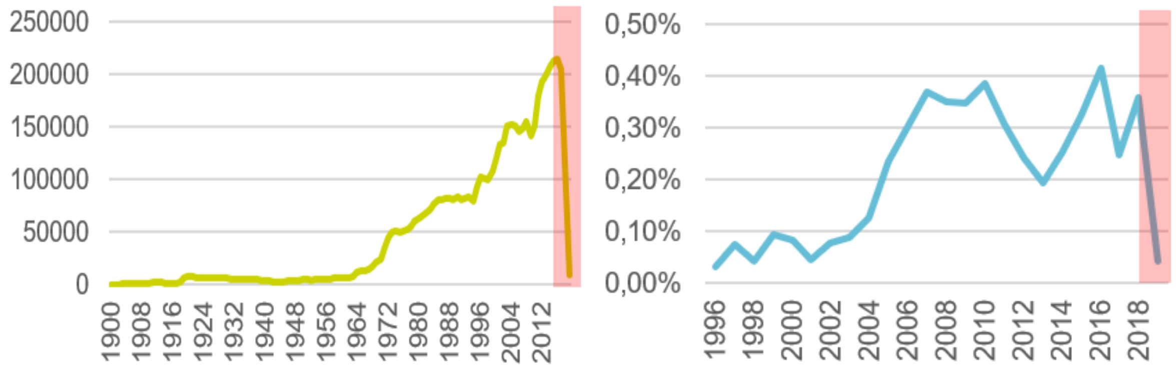
Note: A red screen covers the last year and a half of each graph, since the number of filed patents cannot be considered final, due to the 18 months period of secrecy occurring before a patent application is published. Considering the last two years in the analysis without keeping this in mind would lead to wrong and distorted interpretations.

Figure 11: A. Turkish automotive patents over the years; B. Comparison with total of Turkish patents



As can be seen from figure 11B, except for the biennium 2011-2013, overall innovation has been growing in the country. Specifically related to the automotive industry, patent filing has increased in the last fifteen years, reaching nearly 2000 patents in the last 3 years and representing nearly the 15% of all Turkey's patent filings. As derived from desk research, the recent positive trend is also the result of a supporting action from the government, which financed research (for example through TUBITAK), but also incentivised the filing of new patents and enforced their protection. The decrease around 2013 is likely related to the consequence of a period of economic instability. If that assumption is correct, the fact that the rate of innovation is so dependent on the overall economic development is an indication that R&D capabilities in the country are still fragile and not self-sustained.

Figure 12: Worldwide automotive filed patents (left plot) against Turkey's automotive patents (right plot – expressed as a percentage of the total number of automotive patents worldwide)



Turkey's automotive industry is also gaining an increasing relevance worldwide, both economically speaking and still from a patent-filing point of view. Even though the number of Turkey's automotive patents represents a small percentage if compared to the total number worldwide, it is still possible to see how this fraction has been increasing over the years accounting for almost 0.35% between 2016 and 2018, thus meaning that Turkey has been contributing more and more to the innovation of the worldwide automotive industry. This trend confirms the fact that Turkish companies are moving toward the higher end of the Global Value Chain, developing new original products and components.

4.3 Evolution of the technology landscape

Identifying new technologies

Various data sources have been analysed through text-mining techniques, providing insights into the ongoing changes in the technology landscape of the Turkish automotive sector. First of all, the vast majority of innovations are occurring in the sub-sectors listed in Table 1, where it is reasonable to expect, in the near future, a change in the demand for both new jobs and new skills. The list is ranked according to the intensity of the innovative activity in descending order.

Table 1: Families (clusters) of Turkish automotive patents (ranked from the highest to lowest)

Number of patents	Cluster
738	Data processing
712	Mechanical power transmission
656	Wheel systems
597	Internal combustion engines
543	Sensor control systems
525	Door systems
443	Materials
392	Seat systems
331	Load-carry vehicles
309	Structural parts

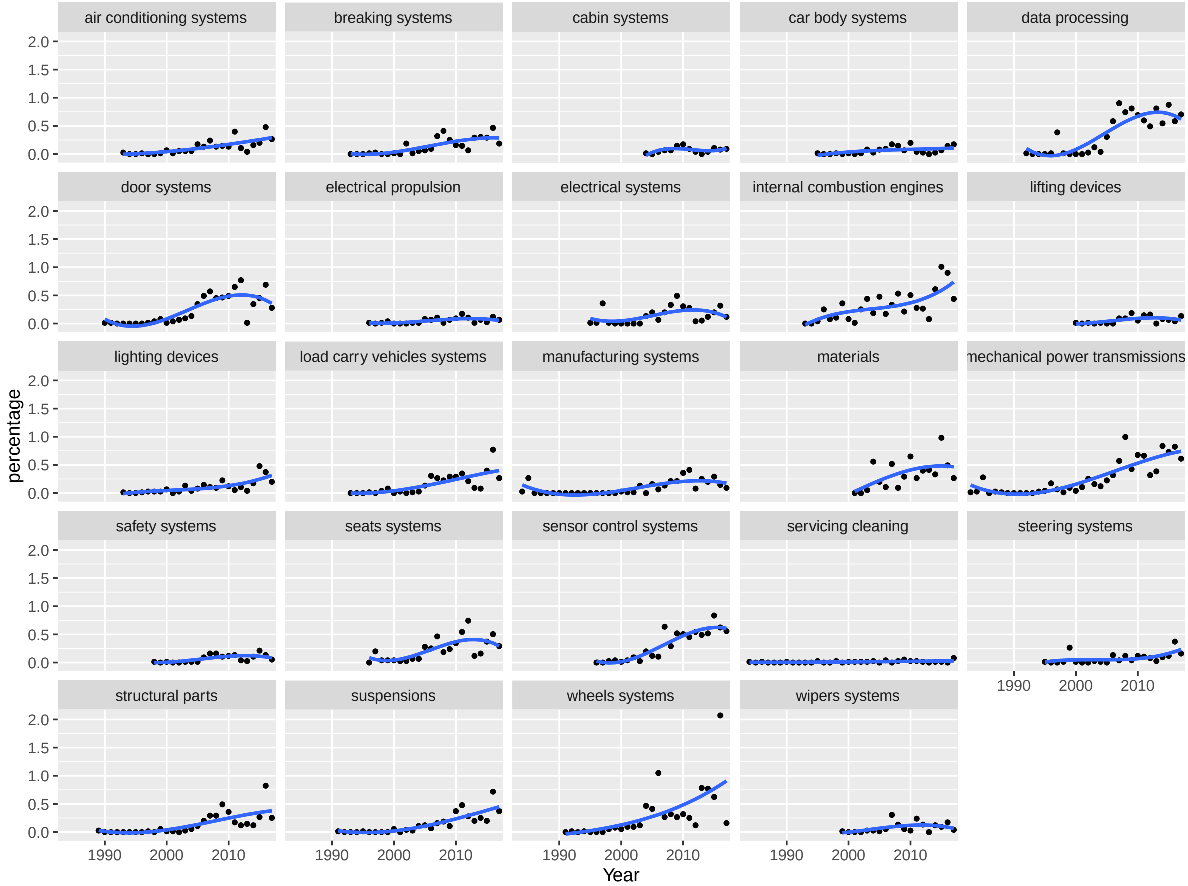
300	Suspensions
277	Braking systems
246	Electrical systems
244	Manufacturing systems
235	Air conditioning systems
210	Lighting devices
143	Steering systems
119	Safety systems
111	Wipers systems
110	Car body systems
92	Electrical propulsion systems
84	Lifting devices
78	Cabin systems
37	Servicing cleaning

Out of all the 24 patent families listed in Table 1, the first half represents 80% of the total number of Turkey's filed patents in the sector. Clusters are consistent with the analysis of the drivers of change in Section 4.1, as well as with the idea of the functional use of technology.

For example, the cluster about data processing is likened to many drivers of change: it reflects the need for developing new business models and processes according to Industry 4.0, it represents the need of developing smarter products, and it shows the importance of privacy concerns related to new models of cars.

Representing the number of filed patents over the years, it is also possible to create temporal trends of each cluster as shown in Figure 13. Compared with Table 1, the representation of trends' clusters provides a more dynamic view. Furthermore, when addressing changes occurring in the sector, trends are the key variable to analyse since they resemble the evolution of a specific concept. Figure 13 confirms that the clusters at the top positions of the list, from *data processing* to *internal combustion engines*, are also those which have been growing faster than the others in recent years.

Figure 13: Trends for specific technologies are shown.



As for the actual technologies that have been or are being introduced, the following list contains all the most recent and most active ones within each of the above clusters, as determined from the text-mining analysis (please note that the same technology can actually appear in more clusters which will increase its significance):

- Vision systems (cameras, software for image analysis)
- User interfaces, displays
- Computer data processing
- Memory units
- Electronic circuitry
- Servomotors
- RFIDs, wireless communication, etc.
- Various types of sensors (position sensors, textile touch pad sensors, speed sensors, fiber optic sensors, acoustic detectors, inductive sensors…)
- Control systems and circuits
- Elastomeric mix for tires
- Plastic resins
- Composites
- Lightweight materials
- Mechanical gears, drive shafts, transmissions
- Valves and injectors
- Springs and pneumatic suspensions
- Tubular bodies
- Lock mechanisms
- Heat transfers

- Thermoelectric modules
- Electrical systems, electrical cables and wirings
- Electric motors (various types, for both power transmission and control system)
- Fuel cells and fuel cartridges
- Energy storage mechanisms, batteries, battery chargers.
- Pneumatic and mechanic brakes
- Brake controls
- Lighting systems, LEDs, LED chips.
- Legged robots
- Robotic arms
- Compliant mechanisms
- Pumpless balancing systems and hydraulic systems.

Among the group of new technologies (at least new for the automotive sector) are all those linked to autonomous driving or in general to the computerisation/smartification of cars: client devices, cameras and other vision systems, user interfaces and displays, computer processing systems. A second group, namely all types of sensors and of control systems, is also related to smart vehicles but linked to the issues of safety, efficiency, and predictive maintenance as well. Not to be overlooked is the relationship of these two groups to the user experience of living in a "smart car". A third group of new materials, such as resins and composites and in particular lightweight materials, are linked to reducing fuel consumption and thus environmental impact.

More traditional technologies, which are still relevant, are all those related to the correct functioning of any vehicle on the road: power transmission and mechanics (gears, shafts); tyres (elastomeric mix); fuel distribution (valves, injectors); suspension systems; air conditioning (heat transfers, thermoelectric modules); locking mechanisms (for a variety of purposes: safety of passengers, anti-theft, and to improve user experience); electric and electronic equipment (cables and wiring, switching modules, circuits, servomotors); lighting systems (LEDs, LED chips).

The interest on greener propulsion systems has led to the research on technologies such as electric motors on one hand, and fuel cells on the other. In parallel with the diffusion of electrical mobility, a relevant area of research concerns energy storage mechanisms, batteries, and battery chargers.

Finally, the manufacturing process cluster contains various technologies related to automation such as legged robots, robotic arms, compliant mechanisms, but also mechanical ones such as pumpless balancing systems or hydraulic systems. Quite a few technologies, in particular control systems, electronic circuitry, memory units, processing unit, RFID, user interfaces, data network, sensors, and all mechanical, electrical, hydraulic technologies are not just growing quickly but appear to be growing transversally – i.e. they are found in multiple applications.

Transversal technologies

Interesting considerations can derive from the understanding of which technology or concept is found in multiple clusters. The main idea behind this further analysis is that technologies/topics that have transversal applications have an added value compared to technologies and topics which are unique to one cluster only. The request of job profiles with specific skills increases in importance if technologies are found and applied in multiple clusters. Specifically, if technologies are found in multiple application fields, their importance is greater since job profiles in the latter will be requested in more than one area. Concerning the automotive sector in Turkey, among those clusters that have the higher number of patents, it is possible to find common technologies:

- Control units, control circuits and control systems recur in five of the clusters listed in Table 1;

- Electronic circuitry, memory units, processing unit, RFID, user interfaces, data network, are recurring in the two main clusters *Data processing* and *Sensors*.
- Sensors themselves appear as technology also in various other clusters (position sensors, textile touch pad sensor, speed sensor, fibre optic sensor).
- All mechanical, electrical, hydraulic technologies (gears, connectors, compressed air, injection systems, electric motors and wirings, etc.) are present across various clusters.

How all the above determines the skill needs of the sector in Turkey is considered in the next section.

Potentially disruptive technologies

In the interviews with key stakeholders and companies, mention was made of those technologies which, in the interviewees' opinion, are likely to come on stream in the foreseeable future and transform elements of the automotive sector – in other words "game-changers". These technologies which were identified are listed below.

- Artificial Intelligence. On the product side, AI is enabling the entire autonomous car business; from the point of view of manufacturing, the technology is reshaping many processes, from quality controls (which will no longer need human inspection) to predictive maintenance.
- Production techniques. The strong international competition leads to continuous optimisation research to reduce costs and save time along the production processes, while at the same time increasing productivity and quality. New paradigms of production such as lean management production or the so called "smart factory" production are adopted. Specific technologies that are being implemented by most companies are the following.
  - Robots and automation. Although it requires initial investments, automation clearly makes production more competitive. Many companies are moving in this direction.
  - Industry 4.0 solutions. The introduction of sensors and other data acquisition devices allows a full digitalisation of processes that can then be managed with software to assure zero defect / zero fault production, maximum efficiency and control, and traceability.
  - Simulation and modelling techniques. Testing activities based on simulators and modelling techniques allow companies to reduce the prototyping costs and guarantee the high quality of the final product.
  - Additive manufacturing. Apart from allowing the production of new specific components with complex geometries or reduced weight, it is reshaping the way prototypes and parts are transferred along the value chain.
- "Smarter" products: digitalisation is related not only to processes but products as well. Due to the high customisation, the business of companies is going to be affected by the introduction of "smarter" products. In the future, components will be more integrated, sharing data with each other. Ever more customers ask for products that have data-gathering capabilities, so that components need to be digitalised and sensors need to be integrated.
- New materials: since the competition for lower prices and higher performance is continuous, for those companies which deal with component production the research of new materials is constant, from composites to plastic embedding electronic circuitry. Due to the introduction of new materials, skills and machines need to be adapted accordingly. For example, for the car of the future it is expected that more kinds of materials will be used in the same vehicle, so new techniques will have to be developed to assemble them together.
- Electric cars and related components: Turkey is determined to pursue the electric mobility business and many companies are working on the development of specific components related to the production of electrical cars: new types of lithium batteries; carriers that allow batteries to be isolated from water, heat, and vibrations; new types of powertrains; fuel cells that could substitute batteries; a range of lightweight components; and so on.

- Self-driving cars or rather aid-assisted driving cars. Many OEMs companies believe that self-driving cars will allow to adapt their commercial offer to customers' needs. Apart from private mobility, another very relevant business is that of that of logistics (trucks) and intralogistics vehicles inside factories or between different buildings.
- AR/VR. Virtualisation is an important technology for the sector, allowing people located in different sites to work together, enhancing for example remote maintenance, as well as enabling new training modalities.

Finally, although not a technology per se but rather a series of methodologies, many interviews highlighted the importance of engineering design, due to the increasing need for Turkish companies to research and develop original and innovative solutions, to gain a competitive advantage and move towards the high end of the value chain.

MAIN FINDINGS OF THE SECTION

- Many factors are influencing the evolution of the sector, from changing customers' expectations and habits to a greater integration into Global Value Chains. The complexity of the scenario calls for long-term strategies also in terms of recruitment and skills management.
- There are a wide range of technologies coming on stream which are likely to transform the automotive sector. Many technologies, not just digital ones (a full list is contained in the section) show a positive trend of adoption, with possible implication for related jobs profiles and skills.
- According to interviewees, certain technologies, from AI to electric and autonomous cars, have the potential to completely disrupt and reshape the production and business models of the sector.
- New technologies and new actors coming from other sectors (such as Google or Apple) are already redefining the traditional market by introducing new models of vehicles. The ability of companies to quickly adapt their model of business and their strategies is critical for surviving.
- Transversal or cross-sectoral technologies (i.e. those required by various sectors or sub-sectors) are becoming increasingly apparent in the sector, as many technologies are inter-related indicating the need of skills covering various technologies.
- The way in which new technologies are introduced and the extent to which they sit side-by-side with older technologies potentially creates a complex set of skill demands.
- The growing trend of innovation, the high volumes of products exported, the international value chain that links Turkey to other global players have the potential to create new jobs in the sector.

5. ONGOING CHANGES IN JOBS AND SKILLS DEMAND

KEY ISSUES COVERED IN THIS SECTION

- An analysis of the main occupational profiles used in the sector, and of the evolution of the skill content of some occupations as a result of the changes occurring in the sector.
- An analysis of new tasks and functions which have emerged in the jobs and/or occupations in this sector, as well as of the old ones that have disappeared (or are likely to disappear).
- The impact of the drivers of change on labour and skills demands in the sector. Whether such changes require higher levels of the same skills or completely new sets of skills.

While the previous chapter looked at the drivers of change in the automotive sector and the associated technological changes, this chapter focuses on the implications of these changes. From both the data mining and the interviews, two groups of occupations emerged as likely to be increasingly sought in relation to the technological changes being introduced into automotive (see sub-section 5.1): (i) technical professional and associate professional occupations (high-skilled workers); (ii) trades workers and machine operators (medium- and low-skilled workers).

Sub-section 5.2 discusses new skill needs emerging for existing jobs and new emerging jobs or occupations. In addition, attention is also given to jobs or occupations which may become obsolete. The last sub-section 5.3 turns to the important role of soft skills in adapting to technological change. Overall, the analysis reveals that significant changes are, and will, take place in the content of a wide range of jobs in the sector resulting from the types of technological change described in the previous chapter.

5.1 Technology-related occupations

Identifying emerging jobs and skill needs

Technology-related occupations comprise those who are competent to manage and use a given technology. The key assumption is that the growing interest in a certain technology (as expressed by patents filed, discussion in scientific papers, and so on) is associated with a growing need for skills associated with the use of that technology. The scale of skill demand will depend upon the adoption or diffusion of the technology, which may vary for a number of reasons (e.g. capital constraints), and the strategic decisions companies make regarding the organisation of work.

There are various possible ways to link the information on technologies derived from text mining to the possible future skill needs. The following procedure has been used. The list of relevant technologies extracted from the literature (see section 4.3 above) has been compared, using semantic matching algorithms (i.e. algorithms able to find semantic connections between different concepts based also on contextual information), to the occupations listed by the European classification system ESCO. Each occupation in the ESCO database includes a description and a list of competences, skills and knowledge considered relevant (either essential or optional) for that occupation. The semantic algorithm looks for matches of each technology with all the concepts associated with an occupation. When a match is found, the occupation is considered associated with the technology. The entire procedure is automated by using ESCO's API, which allows occupational data to be downloaded. The table 2 provides a few examples of the matching process.

Table 2: Examples of the matching process from patent topics to ESCO's skills & occupations

Topic from patents	Matched ESCO skill	Related ESCO Occupation
User interface	Design user interface	ICT system developer
User interface	Design user interface	Embedded systems software developer
User interface	Design user interface	Electrical engineer
Pneumatics	Pneumatics	Fluid power engineer
Pneumatics	Pneumatics	Forge equipment technician
Engines	Engine components	Rotating equipment mechanic
Engines	Engine components	Mechanical engineer
Sensors	Sensors	Electronics production supervisor
Sensors	Sensors	Microsystem engineer
Sensors	Sensors	Robotics engineering technician

Instead of starting from technologies (as extracted from patents) and then matching these with job profiles, an alternative methodology consists of extracting profiles directly from papers about Turkey's automotive sector. In detail, the way this can be achieved is by using a list of skills, tools and technologies which can be found in the O*NET classification (this information can be easily downloaded from the online database) and then each one is searched for in the text of the scientific papers. Once skills, tools and technologies have been extracted from the latter, it is then possible to refer to the O*NET occupations.

The following list collects the technical professional and associate professional occupations (i.e. ISCO groups 21 – Science and engineering professionals, 25 – Information and communications technology professionals, 31 – Science and engineering associate professionals; 35 – Information and communications technicians) which emerged from the data mining (merging matches from both ESCO and O*NET). Please note that the list does not imply a ranking of relevance or intensity; occupations are grouped simply according to their discipline.

- Electrical engineer / technician
- Mechanical engineer
- Sensor engineer / technician
- Automation engineer / technician
- Mechatronics engineer / technician
- Robotics engineering / technician
- Application engineer
- Microsystem engineer
- Instrumentation engineer / technician
- Photonics engineer / technician
- Optical engineer
- Optoelectronic engineer / technician
- Industrial engineer
- Industrial robot controller
- Motor vehicle engine tester
- Motor vehicle engine inspector
- ICT application developer
- ICT application configurator
- ICT network engineer
- ICT intelligent systems designer
- ICT system developer
- Software developer
- Embedded systems software developer
- Industrial mobile devices software developer
- Mobile application developer
- 3D modeller
- User interface designer
- User interface developer

The occupations listed above can be grouped according to three main branches of the occupational classification:

- Engineering professionals, in various fields: electrical, mechanical, sensor, mechatronics, optoelectronic, industrial, automation;
- Information and communications technology professionals (user interface developer, industrial mobile devices software developer) and various types of ICT related profiles which include ICT application developer, ICT system developer and ICT network engineer;
- Technicians and associate professionals such as robotics engineering technicians, industrial robot controllers and motor vehicle engine testers.

Some profiles, such as electric and mechanical engineers, have always been associated to automotive and are easy to understand due the nature of vehicles – implying that even the introduction of new technologies will not diminish the need for those professions on which the sector has been historically dependent. Many other profiles are related instead to the introduction of new technologies: user interface developer, sensor engineer, industrial mobile devices software developer (the latter is related to the growing importance of connected cars on the product side, and the Internet of Things on the process side). Finally, looking at the list there are series of profiles, such as robotic engineers and technicians, which are related to the automation of the production lines.

As well as looking at professional and associate professional occupations, i.e. highly skilled workers, it is also possible to look at medium- and low-skilled occupations, in particular trades workers (ISCO 7 – Craft and related trades workers) and machine operators (ISCO 8 – Plant and machine operators and assemblers). The following occupations emerged as being related to technological change in automotive:

- Diesel engine mechanic
- Electrical mechanic
- Industrial machinery mechanic
- Automotive electrician
- Automotive battery technician
- Vehicle technician
- Security alarm technician
- Pneumatic systems technician
- Heating engineer
- Welder
- Electrical equipment inspector
- Control panel tester
- Control panel assembler
- Electronic equipment assembler
- Motor vehicle engine assembler
- Motor vehicle assembler
- Electrical equipment assembler
- Mechatronics assembler

The lists above highlight an important result: digitalisation and ICT-related competencies are not the only technological area that has a significant impact on skills. On the contrary, the picture that develops is the variety of specialisations and skills required ranging from energy to mechanic, in addition to the demand for those professions traditionally associated with automotive such as vehicle technicians and welders.

A similar analysis could also be extended in principle to the other ISCO groups. Among all, those that could be most involved in the automotive sector processes are managers (ISCO 1), clerical support workers (ISCO 4) and service and sales workers (ISCO 5). However, for the automotive sector the big data analysis did not highlight an impact on the set of competences required by managerial and sales roles. No comments on such profiles emerged from the interviews with the companies and stakeholders either (apart a remark about the need for a change in mentality, especially by management, to deal with the new technologies).

These professions are evidently present within the sector and in some cases play strategic roles. The fact that they do not emerge from the list of professions or from the interviews could indicate a strong focus of the automotive sector on the growth of technical profiles rather than managerial figures or linked to the field of services and sales. The high relevance of technical professions confirms the continuity of the sector with the traditional profiles on which the attention is most focused both when it comes to innovation and when it comes to upskilling of job profiles. Indeed, the new technologies described in section 4 are changing the production process and also the products themselves, but the main characteristic of the product for what concerns the business aspects (selling, import/export, accountancy, marketing, management, dealing with suppliers, etc.) are not affected: an electrical car or a self-driving car will be brought on the market in a similar way to a traditional one.

Skills required by technological professions

As well as looking at the occupations which are associated with technological change, there is a need to know which skills within those occupations are likely to be in demand. One can achieve this by looking at the skills listed for the occupation in ESCO. This is a straightforward exercise (for example robotics professionals – either engineers or technicians – must know how to *assemble robots*, *monitor robots*, *perform test run, record test data etc.*). The process is illustrated in the table 5 below.

Table 5: Occupational skill needs related to a technology: the example of sensor control system

Starting technologies	Related occupations (ESCO match)	Related skills (ESCO match)
Sensors	Robotics Engineering Technician	Assemble robots
		Fasten components
		Monitor machine operations
		Perform test run
		Read engineering drawings
		Record test data
		Set up automotive robot

There are limitations to using ESCO. In many cases, it lists general skills (e.g. assemble robots), while specific competences (e.g. knowledge of different types of sensor devices), which effectively allow going in deeper detail are less well covered. Additionally, the competence level required (e.g. how deep is the knowledge/ability in sensor device required for each of the various occupations it appears in) is another critical factor which is not specified in existing classification systems such as ESCO. In addition to this, the technologies which are likely to be increasingly adopted in automotive may result in a demand for people to work in jobs or occupations which are new and not classified in ESCO, ISCO, or other job classifications.

To address the limitation described above and obtain a more complete picture of the knowledge needed to master a given technology, additional information was obtained from Wikipedia (chosen for its accessibility, the comprehensive amount of information it contains, and the structured way it presents information). More precisely, for every topic (most recurrent terms found in patents) the corresponding Wikipedia page is downloaded using web scraping. Reversing the strategy, it is then possible to provide a more in-depth analysis of the specific skills that will be required by in various technical jobs (as shown in Table 6 below). As in the previous example, the *sensor* technology has been matched to the occupation of Robotics Engineering Technician and its associated skills (according to ESCO), but here the occupation has been further linked to more detailed information about the skills required to master the use of sensors within robotic application.

Table 6: Expanding occupational skills data provided in ESCO: the example of *sensor control system*

Starting ESCO Occupation	Skills associated by ESCO	Needed knowledge inferred from Wikipedia
Robotics Engineering Technician	Assemble robots	Chemical sensors
	Fasten components	Pressure sensors
	Monitor machine operations	MOS sensors
	Perform test run	Temperature sensors
	Read engineering drawings	Image sensors
	Record test data	Monitoring sensors
	Set up automotive robot	Etc.

It is important to note that not all topics/technologies which emerged from the patent analysis have been matched to ESCO competencies and occupations. For example, the technology of charging stations (for electrical vehicles) did not find a direct match (by the way, one of the interviewed companies is specialised precisely on charging stations). It is another indication that existing classifications may not yet encompass references to all the new technologies. That said, to complement the above analyses, job profiles related to technologies can be extracted also from online job postings in an automated way, i.e. through web scraping. More specifically it is possible to search for all job offers (for this task the global employment website Monster.com has been used) which mention, say, charging stations, and extract details of the occupations where this technology is mentioned. Since this approach leads to results which are not readily cross-classified with standard occupational classifications (e.g. ESCO or ISCO), it has not been pursued further in this study, but Table 7 illustrates the possible outcomes using the example of charging stations.

Table 7: Selection of job profiles extracted from online job postings related to charging stations for electric vehicles (web scraping from monster.com, technologies from patent analysis)

Technology not matched in ESCO	Matched occupational profiles in job postings
Charging stations (for electric vehicles)	Senior field service engineer
	Electromechanical assembler
	Construction superintendent
	Software developer
	Fabrication technician
	EV infrastructure project manager
	Material handler
	Assembler

Trends about skills levels and specialisation and the expected impact on labour demand

As clear from the above discussion, almost all the technology-related occupations require highly skilled or at least medium-skilled profiles. This, in turn, leads to the issue of how to train the required professionals, given that demand for them is expected to grow over the medium term (in line with the diffusion of the technologies) and the competences they must possess are very specific. Discussions with stakeholders and companies revealed the existence of two trends:

1. a tendency to be vertically specialised in a specific technology or area but have the capacity to apply it transversally over different jobs, with an horizontal knowledge of many disciplines, (a characteristic defined by companies as a “T-shape” profile – some even require “comb-shape” skills profiles, i.e. having deep expertise on more than one subject);
2. the level of competence required by each worker will increase and become broader, shifting the occupational structure towards more highly skilled profiles.

One reoccurring theme touched upon by stakeholders and companies concerns the importance of the technical medium-skilled profiles within companies. The increase in complexity and in the automation level of the production is expected to increase the need for qualified resources in the sector as well. Accordingly, a new segment of employees is emerging called grey-collar workers because they are required to have more technical expertise than average blue-collar workers. They maintain sophisticated manufacturing hand-skills but more and more they have to navigate an environment full of technologies (e.g. AGV) and have to handle issues that come out in the shop-floor. Professions will change due to digital transformation, so that more and more blue-collar workers will become ‘grey-collar workers’ (for example welding operators will transform and manage welding robots). The workforce composition will change accordingly: the number of low-skilled workers will decrease in favour of a substantial increase in medium-skilled workers (and high-skilled workers).

This transformation will require a structural change in the companies’ organisational structure and HR strategy. Up to now companies have been focusing on high-skilled employees, but without proper training, diversification of duties, and cross-pollination with workers on the production line, the business cannot grow. Focusing on medium-skilled talented employees may help to create a more sustainable organisation. Many companies have indeed started to invest in internal training for upskilling their blue-collar workers. This is also because according to interviews people exiting from the education system do not have a proper set of skills to become grey-collar workers straight away.

In the future, the number of blue-collar workers are expected to decrease while the number of grey-collar workers will increase. However, considering the sum of blue and grey collars together, the total number of workers will probably not change. Since there will be different skills to be developed, a structural change in the distribution of the workforce will occur, but this may not lead to job losses. Indeed, the new technologies present a potential for creating new jobs (such as data scientists or 3d printing designers, cybersecurity experts, sensor engineers, connection network experts…) that were absent in the automotive sector until few years ago. Each new technology can potentially bring both grey-collar and white-collar types of jobs.

Ranking occupations according to potential demand

In the case of technology-related occupations or jobs, it is possible to use data mining results not just to list occupations but also to estimate their relative relevance in the future labour market based on the technological trends described in Chapter 4. To do this, an assumption is made about the relevance of an occupation depending on:

- the technological transversality of the occupation, i.e. its importance grows if it has skills related to more than one technology or topic;
- if the associated skills are essential or optional (as defined in the ESCO classification);
- the weight of the technologies to which it has been matched, in terms of potential future use, as expressed by the normalised number of patents it appears in.

To assign an importance value to each job profile the three conditions must be intersected as shown by the following formula:

$$\text{Importance of Job profile } j\ (y_j) = \sum_{i=1}^{m} T_{ij}\, E_{ij}\, W_i$$

Where:

$$T_{ij} = \begin{cases} \mathbf{1} & \text{If technology/topic } i \text{ is linked to job profile } j \\ \mathbf{0} & \text{otherwise} \end{cases}$$

$$E_{ij} = \begin{cases} \mathbf{1} & \text{If technology/topic } i \text{ is essential to job profile } j \\ \mathbf{0{,}5} & \text{otherwise} \end{cases}$$

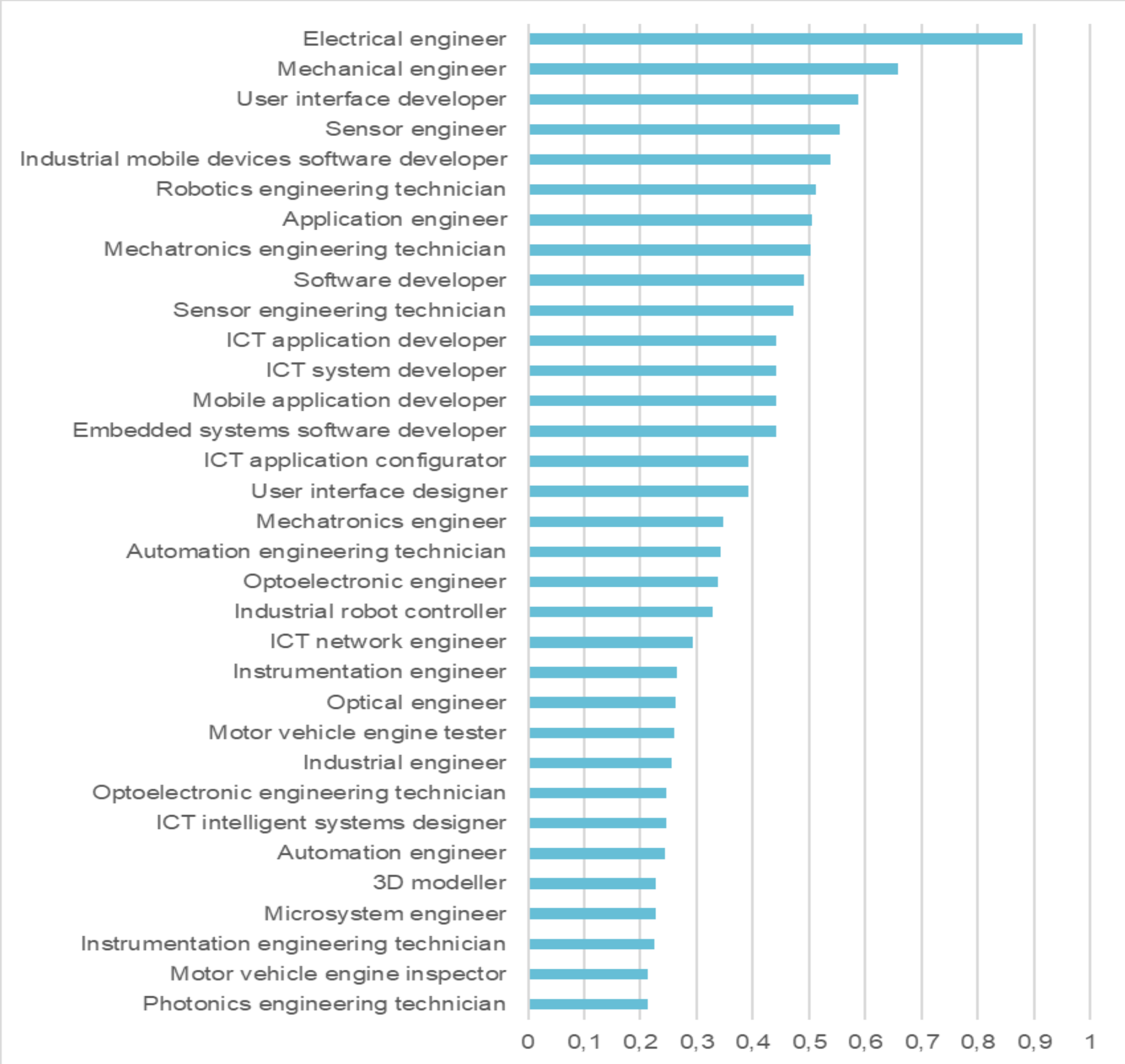
$$W_i = \text{Importance of the technology/topic } i$$

The values of T_{ij} are based on the analysis of Table 2, the values of E_{ij} are based on a sensitivity analysis[52], and the values for W_i are derived from the intensity of the signal for the given technology derived from the patent analysis (see Section 4.3 and Figure 13). Once the scores have been calculated for all occupations it is possible to visualise them using a bar plot which provides a visual understanding of the most relevant occupations in the automotive sector.

The output is shown below in Figure 14 (relevancy scores are normalised and cut above 0,2). The ranking in Figure 14 is indicative of which job profiles are of potential interest but not for the exact order or score. A full-scale analysis of the demand for jobs would require a deeper investigation, use a range of different approaches, and is beyond the scope of the present study. Yet it provides interesting insights: from the plot it is clear that there will be a high demand for electrical engineers, mechanical engineers, user interface developers etc., while occupations such as 3d modeller will still be needed in the future but perhaps less so than the above-mentioned occupations.

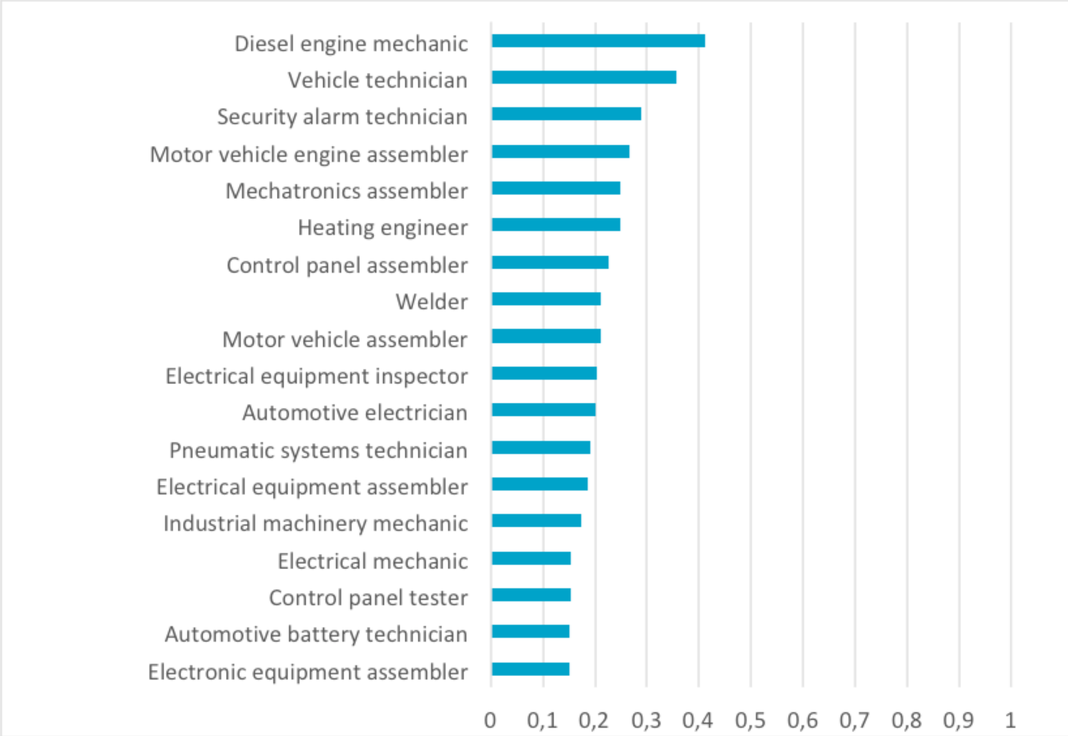
[52] Sensitivity analysis is an iterative procedure for defining the "strength" of the link between technology/topic and job profile. In comparing the ranks obtained from the iterations the lower value is set to 0.5 in order to generate a rank that is consistent with the association between job profiles and technologies.

Figure 14: Ranking of relevance for professional and associate professional occupations from ESCO (on the basis of the technologies they correlate with)



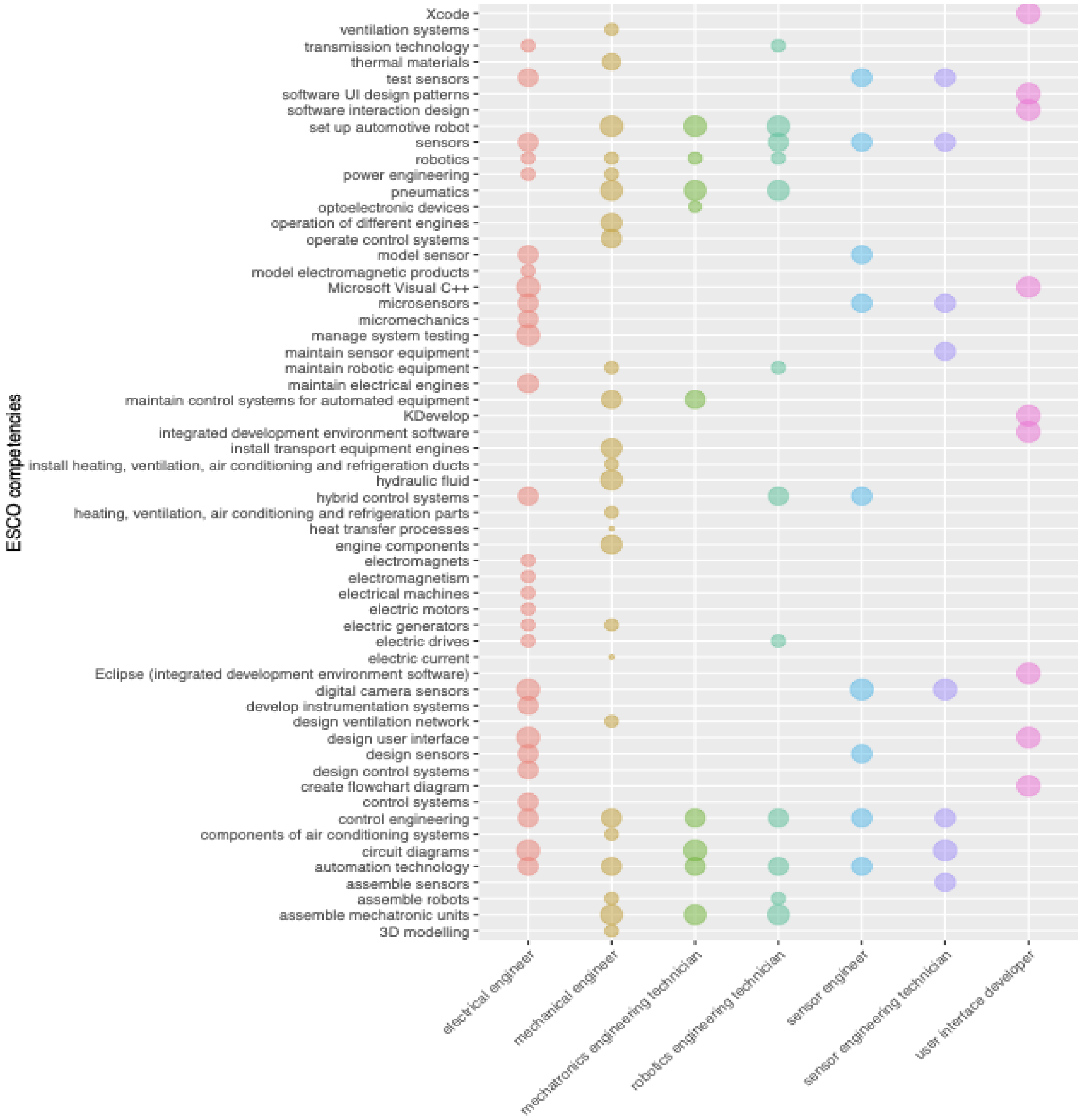
A similar analysis can be repeated for trades workers and machine operators, with the same remarks about the meaning and the limitations of the ranking. The output is shown below in Figure 15 (relevancy scores are normalised and cut above 0,15). In general, these occupations receive a lower score than professional occupations, yet it is still possible to assess their relative relevance: diesel engine mechanics seems to receive a higher ranking than for example automotive electricians.

Figure 15: Ranking of relevance for medium-and low skilled occupations from ESCO (on the basis of the technologies they correlate with)



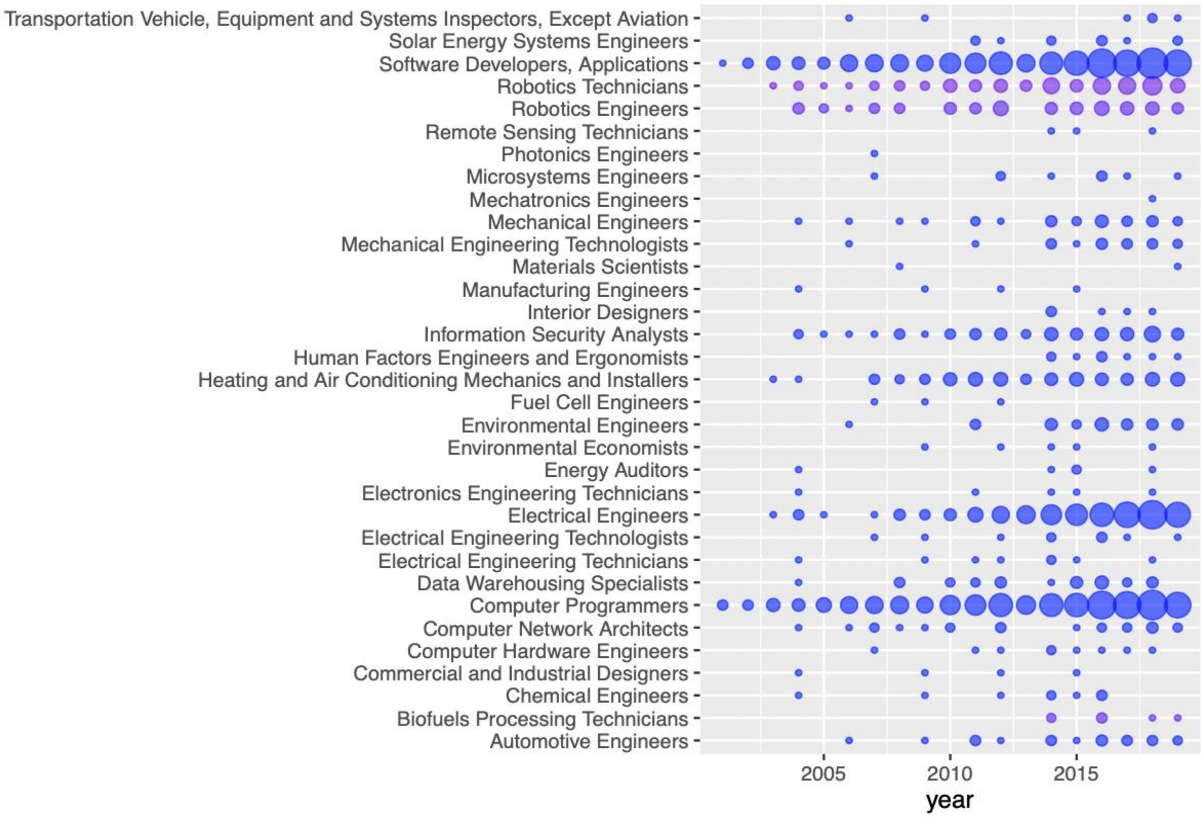
In addition, it is also possible to have a more detailed look at each occupation by analysing how they differ from one another based on which ESCO competence they are connected to. For instance, taking the *electrical engineer, mechanical engineer*, *user interface developer*, *sensor engineer*, *robotics engineering technician*, *mechatronics engineering technician* and *sensor engineering technician* a bubble chart can be used to visualise which skills or sets of knowledge are associated with the occupations, and how important these are based on the technology/topic to which they are connected (see Figure 16). In the figure, the horizontal axis lists the seven ESCO occupations which are matched on the vertical axis with the competences ESCO associates to them. Each competence is associated with a technology according to the procedure described at the beginning of the section, and the size of the bubble at the intersection indicates the relevance of the technology as determined by its occurrence in patents. This second graph shows the distribution of competencies across occupations. For example, it reveals that to work in the automotive sector the electrical engineer needs to have skills related to automation technology, circuit diagrams, electric drives, generators, motors, electromagnetism, how to write code in C++, how to design sensors, how to manage system testing, etc. On the other hand, the mechanical engineer has competencies that are mostly linked to the functioning of engines, control systems, robotics, ventilation systems, and 3-D modelling.

Figure 16: Comparing seven job profiles in terms of their skills (according to ESCO classifications of occupations and related competences), and which competences are the most relevant for each occupation (based on the association with technologies provided by patents analysis)



Finally, the ranking procedure applied to patents and ESCO occupations and shown in Figure 14 and Figure 15 can also be applied to scientific papers and O*NET to obtain the results shown in Figure 17. This chart has a similar purpose to Figure 14 and 15, but instead of aggregating all contributions to create an overall ranking, an alternative visualisation has been chosen, showing the time trend of the references to each occupation. The size of each dot in the chart is proportional to the strength of the signal associated with a given occupation in a given year.

Figure 17: O*NET occupations and their growth over the years in the automotive sector in Turkey (as expressed by their occurrence in scientific papers)



The results are consistent with those obtained through patent analysis. The analysis using O*NET confirms the findings provided elsewhere in this section about the importance of electrical engineers. The fact that computer programmers, software developers and applications developers are also growing is consistent with the analysis of scientific papers and websites which often point out the introduction of new technologies and their impact on products and processes.

O*NET also provides information on the degree of automation (i.e. the extent to which a job can be substituted by a machine). This variable is represented in Figure 17: blue dots representing those with no propensity to being substituted by automation and red a high propensity. In the analysis presented above, the absence of red dots indicates that all occupations have a low risk of being automated, although it has to be noted that low-skilled occupations are not listed in the graph.

Ongoing trends for technology-related occupations

Each big technological development creates a strong need for related occupations and competencies. In this section we review the indications received from stakeholders and companies, which confirm the results of text mining.

The growing trend of smart vehicles explains the fact that some of the most required profiles are *user interface engineers and technicians.* In general, all professions related to IT seem to be growing in interest, also because of the digitalisation of production: *software engineers, embedded software developers, IoT developers and specialists, algorithm developers, network builders, software installers, artificial intelligence scientists, cybersecurity specialists.* A subset specifically concerns data acquisition and management: *data scientist and data analysts, data transmission experts, warehouse engineers.* All the above have been mentioned by companies not only as sought after, but also as very difficult to find, either because of overall scarcity or because the automotive sector is not attractive for those professionals, who prefer to move abroad or to other sectors such as finance or telecommunication.

The other big trend that Turkey's automotive is investing on is that of electrical vehicles, with associated occupations such as *electrical engineers, advanced vehicle electronic experts, electric maintenance specialists, control engineers*.

Since all vehicles will still need mechanical and structural components, more standard occupations for the sector such as *mechanical engineers* and *mechanical design engineers*, *simulation engineers, structural analysis engineers, system engineers, design homologation and test engineers*, are also still in great demand, and expert-level ones are reported to be difficult to find.

The changes in the production techniques also require new professional categories. Alongside the already mentioned ICT-related ones, interviews highlighted the need for skills on remote sensing and robotics, with occupations such as *robotic engineers and technicians, 3d printing engineers, industrial engineers, mechatronics engineers and technicians*. Moreover, engineering design is also becoming very important, and many companies are starting to co-design their product with international OEMs. Thus, the need for various types of qualified engineers will likely increase.

A particular category that was not captured by text mining (probably because not present in ESCO) but is relevant for certain companies is that of *experts in coating technologies*, which are not well-known in Turkey and proved hard to find.

Another finding coming directly from interviews is related to the difficulty of recruiting and keeping experts in maintenance, from *autonomous vehicle maintenance specialists* to *mechanical maintenance engineers.* The reason is that while maintenance tasks require highly skilled technical profiles, the work itself is very hard, with long hours during daytime and shifts also during holidays and nights, and thus many experienced engineers and technicians prefer to avoid it or require very high salaries which are difficult to manage for some companies.

As discussed, it is not only white-collar employees that are affected by the ongoing changes. Indeed, also skilled blue-collar workers and grey-collar workers specialised in the new technologies, are increasingly sought after and are becoming difficult to find. Among them we can find *painters, body shop masters, mechanics, mold makers, founders, CNC operators* and *machine maintenance operators*.

A final remark must be made about non-technical occupations in companies. Sales, business development and customer care roles of course will always be needed in enterprises, as will managers. On the other hand, the technological changes will not require them to possess new technical skills; rather, they will have to change mentality and attitude, understanding the new challenges and opportunities of Industry 4.0, being open to evolve their business models, and base their decisions more on data evidence. Additionally, managers and project executives may need skills on organisational methodologies such as TRIZ, Kaizen, etc.

Comparing the results from interviews and those from text mining, there is a substantial agreement, and it is important to note the variety of the job profiles listed above, including many professions which can be considered traditional in the automotive sector, such as vehicle technicians and welders, as a proof that technology is reshaping all activities and processes.

5.2 Emerging skill needs and skills obsolescence

New skills for existing jobs and new emerging professions

Some professions such as *energy market analyst* and *battery algorithm engineer*, which are not listed in the existing occupational classification, have been mentioned during the focus group discussions. The text mining of section 5.1 also highlighted such occupations. They can be considered as new emerging professions, and more can be expected to come up in the sector, from industrial big data scientists to human-robot interface specialists.

A relevant point is that some occupations, multidisciplinary or at the boundary between two disciplines, such as mechatronic engineers, are deemed more and more important in order to manage complexity and changing working environments. Companies need professionals that can create a bridge between different functions across the value chain, and those kinds of profiles have interactions with different technologies or competencies.

The new technologies will not only create new professions altogether, but will also call for a redefinition of already existing ones. For example, many different types of materials will be used in autonomous cars or electric cars, and they will need to be welded together. The joining process will be one of the key factors for the area, so competencies about the welding processes need to be enlarged. In the same way, the introduction of robots in the production process will transform the manual welder into an operator of robotic welding tools. Basically, it is a transformation of an old process according to new market requirements. This transformation will affect many blue-collar workers, that will need to learn skill related to the new technologies, for example how to install and maintain sensors or how to analyse data collected from the field.

Going even further with the discussion, according to interviews, in the future the digital education for all employees will be a main driver in all sectors. Becoming a digital employee does not mean having to become a computer scientist: all occupations from economists to engineers need to be digitally literate, i.e. to understand the basic principles of robotics and coding (a sort of "third language" alongside native tongue and English).

A new cluster of occupations that will emerge in the future will be that of "translators", not on language but on technologies, and between machines and people. These professionals will understand the logic of a machine/data/software process and translate it to other people, and will be able to translate the user needs into instructions for technicians and developers. New jobs will appear also in understanding the process needs in order to translate them into robotic language. Among such new jobs expected to come up, there are for example industrial big data scientist, robotics specialists and digital mentors. A novel type of specialisation for the data scientist could be focusing on the human behaviour rather than on numerical data: for example, reading from statistics and trying to obtain a pattern, such as customer pattern, selling pattern, and transform the value proposition accordingly.

Because information will be the most valuable asset, and in the future all information may be accessible, positions related to the security of data will be also important such as warehouse keepers that hold the information stored both physically and on the cloud.

Finally, not all new skills required to evolve traditional jobs are related to technologies. Due to globalisation and the integration with global value chains, many companies communicate with foreign customers and suppliers or are opening production plants abroad. For this reason, the knowledge of an international language is becoming a skill that is ever more important for automotive companies. Turkish companies complain about the low level of English (or German) of their employees. In their opinion, the education system does not provide adequate training and only few people can afford the very expensive private English training courses.

In conclusion, through the use of technologies and automation most jobs will change. People at every level will need to nourish their competencies, not only to cope and survive in the changing scenario, but also to increase the added value of their work and get better working conditions.

Skills obsolescence

New technologies will have a significant impact on the automation of many tasks, leading to a redefinition of tasks and occupations related to job profiles. All the interviewees agreed on the fact that most routine task jobs are expected to disappear and be replaced by automation. Among them, machine operators and logistics operators (e.g. warehouse management or forklift driving) will be substituted by robots; visual and quality controls will be carried out by cameras and sensors coupled with AI instead of people controlling pieces manually; in finance and administration processes some obsolete activities will also be automated thanks to Artificial Intelligence. Even for engineers and management roles most of the routine jobs will be held by algorithms and machine learning approaches.

As a consequence, some professions will disappear altogether because of automation. People working directly in the production line are already decreasing, as are call centres or truck drivers; in general, low-skilled occupations are expected to diminish in number.

On the other hand, many occupations will not disappear but change nature: if manual workers on the production line will disappear, they will be substituted by technicians working on electric, electronics, mechatronics, sensors, data programming, for example to manage troubleshooting in their respective areas, or to program robots and cobots, or to repair cameras and sensors. Already now blue-collar workers are working on CNC programs and models so that in the future the physical work will be converted by IT in automatic tasks, still guided by human expertise.

The technical skills of engineers and management will be more related to creating strategies and to human relations rather than analysing big amounts of data and some repetitive tasks. Worker skills should be increased with the use of software, deep learning, and machine learning algorithms. In principle, grey-collar and white-collar employees could collaborate more easily on design and innovation (provided that companies train their blue-collars for technical skills and for creativity skills).

As a complementary information source, the skills classification system O*NET provides for each occupation an expert-based analysis of the likelihood of its substitution by machines – an analysis that other occupational classification systems do not provide. All the profiles which emerged from the analysis present a medium to high level of skills. As a consequence of both their technical nature and the high level of expertise required, such jobs are unlikely to be at risk of being substituted in the future by automation. This was something confirmed in the interviews with companies.

Merging the results of the analysis with the opinions of the companies working in the automotive sector, a great decrease in the employment level is not expected to happen both due to the difficulty of introducing complete automation within the companies and because of the upskilling of the already existing job profiles. Even if some professions are likely to disappear in the future, the activities to be carried out by the employees will be redefined. Companies talk about upskilling and repositioning within the company but not of drastic reduction of the workforce; rather than firing current blue-collar manual workers and hiring grey-collar ones, workers will be more likely trained to acquire more competencies ("It is not about replacing people but giving them new responsibilities").

According to the interviews, for navigating the ongoing changes, attitudes and soft skills may be as important as technical skills. Behavioural skills such as flexibility and willingness to learn will help people in adapting to the challenges that are going to shape the sector.

In conclusion, companies agree that various positions will become obsolete as a consequence of the automation of the activities. Some companies believe that the overall level of employment will stay the same, because at the same time new positions will be created. Other companies think that the total number of employees will decline slightly.

5.3 The role of soft skills

Soft skills are not well defined or described, even in the literature. Thus, everyone tends to understand and interpret them differently, while these skills are also in continuous evolution. Soft skills are named in the literature in different ways: transversal or soft skills, personality traits, character skills, 21st-century skills, life skills, key competences, new mindset or social/emotional skills. This is because these skills relate to individuals' attributes in many instances. They refer, among other things, to: teamwork, communication, initiative, sociability, empathy, collaboration, emotional control and positivity, open-mindedness, openness to learn and to change, flexibility, curiosity, innovation, creativity, entrepreneurship, resilience, planning/ organisation, responsibility, persistence, etc.

What is certain is that assessing these skills is challenging. Work is needed to develop effective tools for measuring, recording and reporting the development of these skills. Despite the difficulty in assessing them, almost all the interviewed companies reported that soft skills were crucial factors for the hiring process. In fact, for some companies, they are as important as technical specialisation.

Flexibility, resilience and agility are considered fundamental for facing the very fast changes of the environment and adapting in a reactive manner. The motivation to learn new things, and the ability to self-learn and learn on the job, are an important component in being prepared to changes.

Problem-solving, analytical skills, design thinking and creativity are essential since the business of the future will be even more based on innovation and the ability to think out of the box.

Emotional intelligence and communication skills will be relevant, especially for leadership roles. Teamwork, project-management and self-management are also important behavioural competences. In a sector that is becoming more and more globalised, it will be critical for future generations to be able to deal with multicultural environments. All the above-mentioned skills will be even more helpful in the future because more people will work remotely, or they will work as freelancers or on a project basis with high flexibility and a project-oriented approach.

Since more sectors are combining with each other, a different mindset is required to be multi-tasking and handle a multi-disciplinary environment, so that employees can obtain knowledge from different areas and on different topics, and work in mixed teams.

Finally, all workers will need to possess a certain degree of digital skills. People will need to follow technologies and be open to the changes, to take decisions with a data-driven approach, and be able to handle data and speak about data more than now.

MAIN FINDINGS OF THE SECTION

- Two main categories of job profiles growing in demand are: technical professional and associate professional occupations; and trades workers and machine operators. Both categories are affected by the technological changes in products (shift towards electrical cars, autonomous vehicles) and in production techniques (Industry 4.0, automation, additive manufacturing) and as a consequence need to increase the number and variety of skills they possess, both on soft skills (e.g. problem solving, flexibility, resilience) and on technical skills (e.g. digitisation related skills).
- A new segment of employees is emerging: they are called grey-collar workers because they are up-skilled blue-collar workers with more technical expertise. The workforce composition will change accordingly: the number of low-skilled workers will decrease in favour of an increase in medium to high-skilled workers.
- There are new jobs emerging which are not found in classifications such as ESCO. This is due to the pace of technological change and high level of specialisation it brings about. New profiles appear fluid reflecting the trend towards multi-disciplinarity and the need to have an integrated knowledge of various technologies. The future worker will need a wider range of skills and

competencies, the ability to mediate and adapt to new situations and roles, and work across disciplines.

- It needs to be recognised that it is not just about the creation of new job profiles. It is apparent that many existing automotive jobs – such as welders – will survive but their task content and skills of these jobs will evolve as a result of technological changes.
- Companies and stakeholders value soft skills (especially resilience, flexibility, problem solving and creativity) with high importance. Thus, the debate on future skill needs is not just about technical skills but the mix of technical and soft skills.
- For most of the interviewed companies operating on the international scene, the lack of or limited English language knowledge is a common challenge.
- Most of the companies believe that the overall level of employment will not decrease in consequence of the introduction of new technologies, but the decline in labour-intensive occupations will be compensated by the increase in higher-added-value ones.

6. MEETING THE CHANGES IN SKILL DEMAND

KEY ISSUES COVERED BY THIS SECTION

- How the changes due to the introduction of technologies affect 'skills utilisation' and working conditions in the sector.
- How businesses meet their new skills needs (new hiring, retraining, etc), and the existing initiatives/cooperation of companies with education and training providers.
- Whether the education and training system is adapting to the ongoing changes and whether it provides an adequate answer to the companies' needs in terms of competences and skills.

This chapter focuses on the company strategies to address and meet their new skill needs and existing initiatives and concrete actions. Please note that all findings presented in this chapter below come from the in-depth interviews and focus group discussions conducted with companies and key stakeholders.

6.1 Limiting factors

Companies were asked which factors were limiting the adoption of the new technologies and in general the development of their business. Most of the companies indicated the shortage of skilled workers as the main factors that inhibit investments. The macroeconomics instability, leading to fewer investments, coupled with the excessively high costs of technologies, are also hampering the introduction of innovative solutions. On the other hand, globalisation and the decreasing international trade are not widely considered as an issue by the companies.

As for the shortage of skilled workers, it applies to both medium and high skills. The shortage of skills is not related to the reputation of the automotive industry, which in Turkey is rather good. One of the reasons is the fact that educational institutions do not provide sufficiently qualified young people, and educational programmes are not up-to-date and aligned with the trends of new technologies and the needs of companies (e.g. mechanical engineers in some cases are reported to know very little about statistics and how to do analysis).

The sector is changing fast, and not just vocational schools but also universities need to adapt their curricula accordingly. The overall impression is that the educational system is indeed trying to improve and update, and this is appreciated, but a deeper collaboration between universities and the private sector would be required in order to be aligned and to prepare students for a future in the industrial world. One of the greatest challenges in the education system seems to be the skill level of the teachers, that are not aware of the industry needs, and this fact has been affecting the students' education. There is a high turnover in teachers as well, so the level of teachers should be maintained over the years to sustain the system.

Regarding the lack of the skills that may recur in the future, the problem is also related to the changing speed of manufacturing and OEMs. The educational institutions should be aligned with such speed of change to have a connection of the curriculum in schools with the real situation inside the plants. Joint workshops between representatives of OEMs and of vocational schools are already held, but the frequency and the depth of those workshops maybe are not enough.

In addition, the shortage of talents is expected to rise in the next years. Some of the most sought profiles (such as ICT-related profiles, data analysts, data mining experts etc.) are more likely to prefer to work in sectors which are perceived to have more stimulating environments than the automotive one (e.g. IT, telecommunication, banking, finance etc.).

Another risk is emigration of highly skilled individuals abroad. Similar to the currently observed trend where the rate of emigrating engineers is steadily increasing, other experienced and highly skilled profiles may leave the country to find better working conditions or career paths abroad, thus worsening the shortage in the white-collar segment.

It was also said that most new graduates prefer to handle office activities rather than difficult physical tasks such as maintenance, and as a consequence they do not deal with the real work of the process.

As concerns blue-collar manual workers, companies seem to experience a high turnover, especially in the geographical areas with important agricultural production. Low-skilled workers often leave automotive companies either to work in the agricultural sector (at least in certain areas) or for other companies, mainly because there is not much difference in salary between jobs in industry and farm. In addition, the loyalty of workers to the company they work for is decreasing in recent times.

Another factor preventing innovative change from taking place is the excessively high costs of the new technologies, a factor that is worsened by macroeconomic instability. Due to market fluctuations, the number of orders is not a sure basis on which to plan big investments. A more stable situation regarding the total number of orders will help companies to invest more. Additionally, macroeconomic instability and political issues also have negative consequences on foreign investments (as happened recently with Volkswagen suspending a planned investment). In the specific period during which the interviews were conducted, the opinion of companies has been affected also by Covid-19 pandemic. Indeed, one common difficulty the companies are facing is the cancellation of orders and related downsizing of production activities. The difficulty to import raw materials (which are generally from East Asia) also reduces the production.

Funding and tax policies are also very relevant. There is a huge taxation for buying new cars that leads to a reduction of the internal market size in Turkey: Car purchases incur a special consumption tax (SCT) which ranges from 45% to 60% for engines up to 1.6 liters and rises to 100%-110% for engines up to 2 liters. VAT of 18% is then applied to the combined figure of pre-tax price plus SCT. This means the effective tax rate on the purchase of a car ranges from 71.1% to 206.8%. In addition, the low profit margins of the sector (4% in best cases) further hamper the possibility for investments.

Finally, resistance to change may act as a limiting factor as well. Actors along the supply chain should be aligned on the need to introduce technologies: in fact, innovation does not always seem to be clearly understood and welcomed by all the subjects. Moreover, global OEMs prefer to work with global suppliers in the technological area, leaving local suppliers unable to invest in technology dealing with production aspects only. The willingness to change is a crucial factor, the lack of which sometimes may lead to some difficulties in investing and developing activities. It can manifest itself both at a managerial level, translating into a lack of investment and foresight, and at a workers' level, as fear of being substituted by robots and automation.

6.2 Recruitment strategies

In general for many automotive companies in Turkey, vocational schools, universities, academic and industry collaborations are all important sources for finding qualified employees.

Recruiting strategies may vary according to the level of the profile that is required. The most common strategy to find the needed skills is the recruitment of new workers who have the right skills. In some cases, high-skilled workers are recruited via head-hunters and networks; medium-skilled workers through career portals and networks of existing employees, and low-skilled workers using newspaper advertisements, networks, and public agencies (e.g. ISKUR – the Turkish Employment Agency).

For some companies, collaborations with universities, research centres and other institutions are the main strategy for meeting their high-skilled staff needs, especially for engineering and managerial roles. The collaboration with universities is fostered by companies because of trustiness and the experience the universities have on education.

A common approach for recruitment is a 3-step interview: the first is an HR selection based on general competencies, the second is a technical interview and the third one is an interview conversation with management based on personality and soft-skills of the candidate. More structured companies have a HR manager and apply different recruitment strategies for different job levels. The general strategy descends from the definition of the company's strategic plan: which products and technologies should be present in the company, ten years from now. As a consequence of the plan, the HR department prepares a gap analysis chart for each job title, considering both engineering and management capabilities. Through such charts, the company manages recruitment and training programmes according to the competencies gap.

There are few cases in which companies try to get the proper practical experiences by hiring people from abroad. It is the case of a company working on forging processes, knowledge of which is not widely spread in the country.

In most cases, after recruitment, further training programmes are provided for new graduate engineers both in managerial skills and technical skills, also to provide more operational and focused skills. Internal trainings are also arranged for sharing the knowledge of more senior and competent employees. Automotive sector associations also have excellent training programmes on a regular basis and open to everyone. One such example is the Turkish Automotive Suppliers Association (TAYSAD) which organizes and delivers high quality training programmes since 15 years upon the request of their members. The topics of training is determined through conducting a survey among its members in every few years, which are then included in the training plan of TAYSAD.[53] This is a big advantage for the sector, as the associations of employers in Turkey are quite active providing many services for their members. Like TAYSAD, Automotive Manufacturers' Association (OSD) is very active for its members, so as the *Turkish* Employers' Association of Metal Industries (MESS). The latter organizes special training programs for the digital transformation and competence development in companies through its MESS Technology Center and online platform.[54]

6.3 Training strategies

A common perception is that a gap in competencies will always be present even if the educational system (both universities and secondary education) makes effort to adapt to the sector's new emerging needs, due to the fast pace of technical change. Hence companies should take initiatives for filling the gap with training programmes. The issue of improvement of skills for white-collar, grey-collar and blue-collar workers is a common problem for the industry in Turkey. As an example again, TAYSAD organises meetings on the topic twice a year, and it is attended by more than 400 companies in the sector, including international ones.

According to interviews, the management of companies is sometimes responsible for suboptimal training strategies. In fact, every manufacturing company has a business plan and defines a budget for training activities. Compared to the budget, companies tend to spend less in training because it is

[53] See the related website page of TAYSAD at https://www.taysad.org.tr/en/egitim/3. TAYSAD is also one of the key members of the European Cluster Initiatives including for training. See at https://www.clustercollaboration.eu/cluster-organisations/automotive-suppliers-association-turkey-taysad

[54] For more information, see https://www.messteknoloji.org.tr/

seen as a cost driver. It has been suggested that people change their attitude and look at training activities as investments on the future of the company.

One of the most recurring comments made by companies is that during the university period, students are not taught how to learn on the job. Some mechanical engineers see a plant for the first time after their graduation. During internship periods they prefer to handle office activities and they do not deal with the work on the line. After-hiring adaptation of new recruit takes too much time and money, effort, and resources for the companies. From observations, it takes approximately five years after graduation to turn a freshly graduated mechanical engineer into a “real” mechanical engineer.

Students need both technical and soft skills, and above all they need to “learn how to learn” because they are just graduated with theoretical knowledge. The causes are to be found in the educational system: professors and lecturers at universities do not have experience of the real needs of the sector.

Many strategies are adopted by companies to improve the situation. The most common solutions for training people and reducing the skill gap are internal (in-house) training, or buying training from a variety of external subjects, depending on the budget or on the topic, from Universities and Research Institutes to engineering consultancy companies.

In other cases, training can be carried out by staff within the company if there is a highly experienced person in a given area of expertise. Learning on the job strategies are often adopted: new hires are often supported by expert figures who can follow them during the course of the activities sharing their knowhow. Job rotation programmes for the internal workforce are also adopted. Some companies have also developed an internal expert community regarding engineering issues.

Companies are also interested in soft skills and try to organise training for them as well. One of the companies has developed a special structured training programme dedicated to three different skills sets: emotional intelligence, AQ[55] and digital intelligence. The adaptability programme is important for allowing employees to face future challenges. The agility issue, that is also addressed by the programme, is split into major topics: mental agility, i.e. analytical thinking ability, focus on listening and finding a proper solution; people agility, because team management is important especially for remote working; change agility, that is the capability to understand the strategies, deal with uncertainty etc. and also result agility, training people to develop methods to change solutions and take initiative. Digital intelligence is also part of the training programme and includes digital security, how to become a digital citizen, how to use social media properly, making communications through digital channels, etc.

The use of open source online training opportunities (web based) is a solution that is already adopted by some companies and it is expected to be adopted in the future even more, due to the increasing diffusion of smart working.

Finally, many companies have also organised, or are planning to do so, an own internal academia for filling the skills gap: once students have completed their vocational school’s path they attend the company’s academia learning about technical issues and developing competences in soft skills like resilience or agility. Regarding the future, for meeting ever more customised skills needs, most of the interviewed companies intend to extend the concept and set up an in-house training facility, their own

[55] Adaptability Quotient (AQ) is a scientific measurement of adaptability in individuals and teams, first created by Amin Toufani. The concept was publicized through Toufani's lectures over five years at Singularity University and subsequently at Adaptability University, which defines AQ as "the ability to realize optimal outcomes based on recent or future change." (Source: Wikipedia)

training centre for the entire internal workforce. It would allow companies to organise flexible and customised internal academies to share the knowhow within the plants.

6.4 A final word on the findings

Various good practices are being carried on in the country. For example, since the automotive is one of the leading sectors in Turkey, the Vocational Qualification Authority is carrying out some important supporting activities such as the definition of 33 vocational occupational standards in the automotive sector and 27 national qualifications adapted.

Other good practices emerged during the meetings with stakeholders and companies to meet the future skills needs of companies. They vary from long-term internship opportunities offered to vocational high school students to academies that provide contemporary standards of education, classrooms for theoretical and practical applications, workshops, computer rooms, conference halls, libraries, and other areas for social life. These examples of collaboration show that TVET providers have a role to play in supporting the automotive ecosystem. Still, there is a widespread concern that the education system has some difficulties in adapting to the fast change of the sector.

As already mentioned in the previous sections, the training offered by sector associations, chambers of commerce or employers' associations, often for free, are very important, so as the training offered by the (private) providers of new technologies. The vocational and technical education and training system has a very important role to play in this picture. The 2023 Education Vision, announced by the Ministry of National Education in 2018, provides a new road map for vocational and technical education that would be constantly updating itself according to the country's priorities. Strengthening the collaboration with stakeholders, including private training providers and the industry, and improving applied training and qualifications in VET is among the priorities set by the 2023 Education Vision.

The needs of profiles and competencies by companies are constantly changing, for this reason a close collaboration between companies and the academic world should be encouraged and pursued. The establishment of some industry-based taskforces giving specific training certifications to teachers would be useful to maintain the proper level of expertise for teachers. As an example, TAYSAD manages the working groups in such topics as digital transformation, university-industry collaboration, and promotes international collaboration projects aimed at developing collaboration on new technologies funded by IPA. At the same time companies need to encourage workers to pursue personal development on technical issues and how they can make their work more efficient and more unique. Employees at any level need to nourish their competencies because it will increase their added value. Like technical competencies, soft skills are becoming even more important since the adaptability and the willingness to learn of people are going to be the basic traits for the future employees.

It is hoped that these findings will raise awareness of policy makers and practitioners about the changings skills needs in the automotive sector and provide food for thought especially in relation to the ability of education and training system to face them and to prepare workers who will be fit for the new jobs and occupations. Possible actions could include:

- the development of learning units (modules) for up-skilling/reskilling professionals (including low, medium and high-skilled jobs) in the sector;
- the identification of specific gaps in the existing curricula of HE and TVET system as well as higher emphasis on core skills and soft skills in the general education system;
- an increased focus on new emerging technologies (as identified above) and to transversal technologies;
- the inclusion of work-based learning modules or initiatives across different education levels (including for higher education students);

- the development of specific curricula and upskilling mechanisms for grey-collar workers, given the increasing complexity of their work and because of their increasing relevance within the organizational structure of the companies;
- the development of new qualifications by the Turkish Vocational Qualifications Authority in partnership with the universities, TVET providers and companies in the sector;
- better career guidance and information about job and career opportunities;
- specific support mechanisms to support transition from job to job, especially in case of low-skilled workers;
- the systematisation of existing good practices;
- the establishment of more concrete mechanisms to enhance the collaboration between enterprises and education providers - the collaboration needs to be purposeful, not just to show on paper and social responsibility for the sector etc. This could take the form of specific Skills Strategic Partnerships Formats, e.g. a ‘Pact for Skills’ that is similar to the one recently announced within the EU, open to any type of sector’s organisation active in any field of education, training and youth or other socio-economic sectors as well as to organisations carrying out activities that are transversal to different fields.

MAIN FINDINGS OF THE SECTION

- There are various factors which may be constraining growth in the automotive sector. Most companies indicate a shortage of skilled workers as the main limiting factor. One of the reasons is that educational institutions do not provide sufficiently qualified candidates to industries. Other factors such as the emigration of high-skilled workers, and lower attractiveness of automotive sector for the high-skilled with respect to other sectors also play an important role.
- One problem related to the skills mismatch is due to the speed of technological changes: the educational institutions should be aligned with such speed and should connect the curriculum in schools with the real situation inside the plants.
- Companies follow various strategies to find their skill needs, ranging from recruiting new graduates from universities to job advertisements posted on online job portals. They change according to the level of skills/ job profiles required.
- Links with educational system are present in the sector. At the same time it seems that educational system is not able to provide all the competencies required by the industry. After hiring, all new graduates at different levels require training on the jobs. Thus companies provide on-the-job training, mentoring and coaching after recruitment for introducing the new graduates to the job environment. A stricter collaboration between the education system – both university and vocational schools – and companies is advisable.
- Companies try to compensate the skill gap by widening their training strategies by providing in-house learning and on-the-job training, or buying training from external subjects, such as private companies or universities, or even setting up their own internal academies and training centres. The last strategy is quite common in the automotive sector.

ANNEX 1 – KEY STAKEHOLDERS CONSULTED

The following table lists all the stakeholders which were met during the project, either during the focus group discussions or bilateral online interviews with the Turkish representatives.

NO.	ORGANISATION (alphabetic order)
1.	AKT Centre of Applied Research A.S.
2.	Aktas Holding
3.	Anadolu University
4.	CoşKunöZ Education Foundation
5.	European Bank for Reconstruction and Development
6.	Ermetal Automotive
7.	EU Delegation to Turkey (Education and Training)
8.	European External Action Services (EEAS) / The EU Delegation in Turkey
9.	Gazi Üniversitesi
10.	Honda
11.	Inci GS Yuasa
12.	Inci Vakfi
13.	Industrial Automation Manufacturers' Association (ENOSAD)
14.	International Labour Organization
15.	Investment Office of the Presidency of the Republic of Turkey
16.	ISKUR (Turkish Employment Agency)
17.	IT&L
18.	Kompozit Sanayicileri Derneği
19.	Maxion Wheels
20.	Maysan Mando
21.	Mesleki Yeterlilik Kurumu (Republic of Turkey Vocational Qualifications Authority)
22.	Millî Eğitim Bakanlığında (Republic of Turkey Ministry of National Education)
23.	Otokar
24.	Otomotiv Sanayii Derneği – OSD (Automotive Manufacturers Association)
25.	Standard Profil A.S.
26.	Temsa
27.	Tofas - Türk Otomobil Fabrikası A.Ş.

28.	Türkiye İstatistik Kurumu - TÜİK
29.	Türkiye Metal Sanayicileri Sendikası – MESS (Turkish Employers' Association of Metal Industries)
30.	TurkTraktor
31.	United Nations Industrial Development Organization - UNIDO
32.	Università del Piemonte Orientale
33.	Vestel
34.	Yesilova

ANNEX 2 – GLOSSARY

API – stands for Application Programming Interface (API), a computing interface that defines and allows interactions between multiple software without the need for human intervention.

Artificial Intelligence – is a general term used to describe a variety of technologies and approaches that allow computers to solve complex tasks (usually associated with higher cognitive levels),for example: recognition of objects or patterns; classification of entities; simulation and modelling of situations; predictions of future behaviours; generation of constructs similar to existing ones.

Cognitive bias – is a systematic pattern of deviation from norm or rationality in judgment. Cognitive biases are considered by many authors as linked to the normal functioning of the human brain and thus can arise in any activity involving human judgement.

Competence – means "the proven ability to use knowledge, **skills** and personal, social and/or methodological abilities, in work or study situations and in professional and personal development" (European Qualifications Framework). While sometimes used as synonyms, the terms **skill** and competence can be distinguished according to their scope. The term **skill** refers typically to the use of methods or instruments in a particular setting and in relation to defined tasks. The term competence is broader and refers typically to the ability of a person – facing new situations and unforeseen challenges – to use and apply knowledge and skills in an independent and self-directed way.

Cross-sectoral (knowledge, skills or competences) – is one of the four levels of **skills** reusability identified by the **ESCO** initiative, whereby reusability it is meant how widely a knowledge, skills or competence concept can be applied in different working contexts. Cross-sector knowledge is relevant to occupations across several economic sectors, whereas sector-specific or occupation-specific knowledge is restricted to one specific sector or **occupation**. See also **Transversal knowledge**.

Cross-sectoral technology – adopting the concept of **cross-sectorality** from **ESCO**'s **skills** reusability levels, the term indicates a technology that finds application in many different economic sectors (e.g. Control unit or sensors).

ESCO – is the **E**uropean multilingual classification of **S**kills, **C**ompetences and **O**ccupations. ESCO works as a dictionary, describing, identifying and classifying professional **occupations**, **skills**, and qualifications relevant for the EU labour market and education and training, in a format that can be understood by electronic systems. It lists over 3000 occupations and 13.000 skills and competences). For more info, see https://ec.europa.eu/esco/portal/home.

ISCO – stands for International Standard Classification of Occupations and is an International Labour Organisation (ILO) classification structure for organising information on labour and jobs. It is part of the international family of economic and social classifications of the United Nations. It contains around 7000 detailed jobs, organised in a four-level hierarchy that allows all jobs in the world to be classified into groups, from 436 lower-level groups up to 10 major groups.

Job – is a set of tasks and duties performed, or meant to be performed, by one person (ISCO-08).

Job profile – is the description of a particular work function, developed by the employer or by the HR department of a company, that includes all the elements deemed necessary to perform the corresponding **job**. In particular, it includes general tasks, duties and responsibilities, required **qualifications**, **competences** and **skills** needed by the person in the job.

Job title – is the identifying label given by the employer to a specific job, usually when looking for new candidates to the position. In the absence of standardised nomenclature, it can coincide with either a description of the **job**, or the **occupation** group the job belongs too.

NACE – a four-digit classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics, provided by Eurostat. Economic activities are divided into 10 or 11 categories at high-level aggregation, while they are divided into 38 categories at intermediate aggregation.

Natural Language Processing (NLP) – is an interdisciplinary field at the intersection of linguistics, computer science, information engineering. NLP deals with the interactions between computers and human (natural) languages, in particular how to program computers to process and analyse large amounts of natural language data, starting from the identification of the grammatical and logical parts of speech within a sentence, up to the complex representation of semantic relationships between words.

O*NET – stands for Occupational Information Network, a free online database of occupational requirements and worker attributes. Currently the online database contains 1016 occupational titles, each with standardised and occupation-specific descriptors, covering the entire U.S. economy. It describes occupations in terms of the skills and knowledge required, how the work is performed, and typical work settings. It can be used by businesses, educators, job seekers, human resources professionals, etc. It is a program to facilitate the development and maintenance of a skilled workforce, developed under the sponsorship of the US Department of Labour/ Employment and Training Administration (USDOL/ETA). For more info, see https://www.onetcenter.org/, https://www.onetonline.org/.

Occupation – according to ESCO, an occupation is “a grouping of jobs involving similar tasks, and which require a similar **skill** set”. Occupations should not be confused with **jobs** or **job titles**. While a job is bound to a specific work context and executed by one person, occupations group jobs by common characteristics (for example, being the "project manager for the development of the ventilation system of the Superfly 900 aircraft" is a job. "Project manager", "aircraft engine specialist" or "heating, ventilation, air conditioning engineer" could be occupations, i.e. groups of jobs, to which this job belongs).

Occupational profile – an explanation of the **occupation** in the form of: description, scope, definition, and list of the knowledge, **skills** and **competences** considered relevant for it. Each occupation in the **ESCO** database also comes with an occupational profile that further distinguishes between essential and optional knowledge, skills and competences.

Profession – an **occupation** requiring a set of specific **skills** and dedicated training.

Qualification – is the “formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards” (European Qualifications Framework).

Regulated profession – A profession is called regulated if its access, scope of practice, or title is regulated by law.

Semantic matching – is a technique used in computer science to identify information which is semantically related.

Skill – means “the ability to apply knowledge and use know-how to complete tasks and solve problems" (European Qualifications Framework). They can be described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments). While sometimes used as synonyms, the terms skill and **competence** can be distinguished according to their scope. The term skill refers typically to the use of methods or instruments in a particular setting and in relation to defined tasks. The term competence is broader and refers typically to the ability of a person – facing new situations and unforeseen challenges – to use and apply knowledge and skills in an independent and self-directed way.

Soft skills – are usually associated with **transversal skills**, and considered the cornerstone for personal development, also within the context of labour and employment. To distinguish them from other knowledge-based basic skills, they are often referred to as social or emotional skills. They can be further classified into personal skills (e.g. problem-solving, adaptability) or interpersonal ones (e.g. teamwork, leadership).

Text Mining – is a general term indicating a variety of techniques that allow computers to extract, discover or organise relevant information from large collections of different written resources (such as websites, books, articles). The first part of any text-mining process implies the transformation of texts in structured representations useful for subsequent analysis through the use of **Natural Language Processing** tools. Sometimes **Artificial Intelligence** techniques are used to perform Text-Mining tasks more effectively.

Transversal (knowledge, skills or competences) – is the highest of the four levels of **skills** reusability identified by the **ESCO** initiative, whereby reusability it is meant how widely a knowledge, skills or competence concept can be applied in different working contexts. Transversal skills are relevant to a broad range of **occupations** and sectors. They are often referred to as *core skills*, *basic skills* or *soft skills*, the cornerstone for the personal development of a person. Transversal knowledge, skills and competences are the building blocks for the development of the "hard" skills and competences required to succeed in the labour market.

Transversal technology – adopting the concept of **transversality** from **ESCO**'s **skills** reusability levels, a transversal technology is relevant to a broad range of **occupations** and sectors and is a building block for more specific technologies (e.g. computerised image analysis).

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Where to find out more

Website	**www.etf.europa.eu**
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