THE FUTURE OF SKILLS

A case study of the automotive sector in Turkey

Manuscript completed in March 2021.

PREFACE

In November 2018 the European Training Foundation (ETF) launched an international review to investigate how global trends impact on developing and transition economies, and to discuss what actions they need to take to prepare their citizens for a changing world and manage the transition into an uncertain future. The ETF conference 'Skills for the Future: Managing Transition' concluded that monitoring and understanding evolving skills demands – driven by new technologies, the prerequisite of greening our economies and societies, interrelated economies and changing labour markets – are indispensable for action (see ETF, 2018a; 2018b). Gathering and assessing reliable intelligence on evolving skills demands through traditional methods of data collection and analysis and the exploration of innovative approaches are essential for responding to and anticipating existing and upcoming changes, and for making the necessary adaptations to education and training systems (ETF, 2019a).

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

The study concentrates on changing skills needs and documents changes in occupations and related skills driven primarily by technological innovation. It does not assess the volume of employment and skills demand, but rather provides qualitative information on occupations and the types of skills required to perform these roles. The study also provides some information on how companies find (or not) the skills they need and how they reskill their employees to meet the new needs of the labour market. However, it does not set out 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 that are most likely to be affected by technological change, as well as the changing skills requirements for medium- and low-skilled occupations, in particular craft and related trades workers (International Standard Classification of Occupations (ISCO) group 7, e.g. mechanics and electricians) and plant and machine operators and assemblers (ISCO group 8). Its aim is to raise awareness about changing skills demand, identify markers 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.

This study is part of a series of studies that the ETF is implementing in its partner countries, and which focus on economic sectors that present pockets of innovation and the potential for further development (see e.g. the Israel agri-tech sector study (ETF, 2020a)). It is based on a new methodological approach that combines traditional research methods (desk research, data analysis and interviews) with big data mining techniques. The use of big data analysis is relatively new and experimental, but its application is increasing in labour market-related research. Despite its limitations, it can provide fresh insights as well as real-time information on recent trends. The shortcomings of each research tool are compensated for by using a mixed methodology, in which the results coming from different instruments are compared and verified from various angles. The result is a consistent set of findings, corroborated by different research tools, on emerging trends and technologies in the sector, changing skills needs, new and obsolescent jobs, and the existing skilling and reskilling practices found in companies.

Fondazione Giacomo Brodolini and Erre Quadro have been working with the ETF to conduct this case study. They brought together their international and national researchers on Turkey, in addition to the ETF's team of experts. The study was carried out between January and December 2020, and this report was drafted by Riccardo Apreda, Liga Baltina, Riccardo Campolmi, Chiara Fratalia and Terence Hogarth, with inputs from the national experts Mustafa Gökler and Süheyl Baybali. ETF experts Ummuhan Bardak, Francesca Rosso, Lida Kita and Anastasia Fetsi provided extensive comments and contributions during the drafting process, and the final draft was peer reviewed by ETF experts Susanne Nielsen, Manuela Prina and Olena Bekh and edited by Ummuhan Bardak.

The report documents all steps of the research and presents the findings in a detailed manner. This is because the ETF wants to draw the attention of all stakeholders (e.g. researchers, practitioners and policy makers alike) to the changing skills needs in the automotive sector and to provide an example of how to identify these new skills needs by using different methodologies. The findings of the report will not only raise awareness among stakeholders, but will also provide food for thought for educators and trainers faced with changing skills demands and responsible for preparing workers for the new jobs and occupations to come. Shorter and more targeted papers (e.g. policy briefs, infographics, a methodological note) will follow later after all the case studies have been completed.

Last but not least, the ETF would like to thank all the public and private institutions, individuals and companies (see the list in Annex 1) for sharing information and opinions on the topic, and actively participating in the two ETF online workshops organised in May 2020 and the final webinar organised to review the results in October 2020. In particular, the sector-specific knowledge of the national experts (Mustafa Gökler and Süheyl Baybali) enabled the ETF to reach the right companies and institutions in the sector, who kindly shared their experiences in the bilateral interviews. As a result, the information and statistics provided by Turkstat (Turkish Statistical Institute) and the automotive sector associations (e.g. OSD, TAYSAD and OYDER), as well as the 20 companies that kindly agreed to be interviewed, provided vital sources for the study. 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 European Union (EU), this sector employs around 2.5 million people directly in the production of vehicles. The automotive industry is also the largest and most important manufacturing sector in Turkey, which has a long history of producing motor vehicles, either by indigenous companies or major foreign brands investing in the country. 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. The sector has therefore played an important role in transforming the economy into a relatively hi-tech one with a substantial research and development (R&D) capability.

For the purposes of this study, and in the terminology of the NACE classification of economic activities, the following two sub-sectors are included in this study of the Turkish automotive sector: NACE C-29 (Manufacture of motor vehicles, trailers and semi-trailers) and NACE G-45 (Wholesale and retail trade and repair of motor vehicles and motorcycles). As such, the study encompasses the manufacturing of all types of vehicles and their production processes as well as the trade and aftersales market. All the actors in the value chain have been included, from OEMs to the suppliers of components and services, as well as those involved in the trade and repair of vehicles (wholesale and retail sales). The analysis has focused on all the job profiles and skills that apply to the automotive sector and which may be affected by technological changes.

The numbers employed in the Turkish automotive sector change significantly according to the sources consulted. Despite examples given to differing numbers, this report uses labour force survey (LFS) data as the main source of employment figures, as they are more comprehensive and potentially capture the most complete and realistic picture of the sector. According to Turkstat LFS statistics, 812 000 people were employed in the automotive sector in 2019, which accounts for around 2.9% of the total employment in Turkey. Out of this group, 33.6% work for the manufacturing segment (273 000 in NACE C-29), and the rest in the trading area (539 000 in NACE G-45). The worker profiles of the two sub-sectors are quite different – for example, the manufacturing segment employs workers with much higher levels of skills, while, to a large extent, the trading side includes workers with low educational attainment (less than upper secondary level). Both sub-sectors are heavily male-dominated, with the share of female workers only reaching around 10% across the whole sector. The automotive industry is also dominated by young workers, with more than three-quarters of employees belonging to the 15–44 age group.

The sector has grown very rapidly over the past 10 years compared with employment across the economy, and creates relatively skilled and decent full-time jobs. Indeed, employment in the manufacturing segment of the automotive sector has increased almost 43% since 2009, as against 31% in the trading field (with both figures higher than the 24% overall increase in total employment). Furthermore, the quality of the jobs created in the manufacturing sub-sector tends to be good and characterised by higher salaries. This is also a sector, especially in the manufacturing segment, which employs many medium- and high-skilled people in the following two occupational groups: (i) associate professionals/technicians; and (ii) craft and related trades. At the same time, the sector faces several challenges – not just in Turkey but worldwide – given the tremendous technological changes which affect both the products and processes used in manufacturing, and the new business models associated with sales and after-sales services. Ultimately, this has implications for the skills the whole sector will need.

The findings presented here explore the ways in which technological change has affected the automotive sector, in terms of both its value and production chains, and how this is reshaping the demand for skills in Turkey. The study looks at how existing players in the automotive market have had to update their manufacturing methods as well as the selling and servicing of 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 from their predecessors.

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

- a review of trends in output, employment and skills based on national statistics and various existing reports (national and international);
- big data analysis using text mining techniques to collate information from patent data and scientific papers on emerging technological trends, and identify the skills associated with those technologies;
- 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 needed to use them.

The study thus provides a comprehensive, forward-looking assessment of skill needs in the automotive sector in Turkey.

Drivers of change and emerging technologies

Technologies employed in a workplace have a significant bearing on the skills workers will need to use. To compile a list of technologies used in automotive workplaces – and how these are changing – requires an analysis of the drivers of change. This helps to highlight 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, including both technological and non-technological factors:

- the introduction of new technologies, both with regard to the products (electric cars, smart cars, etc.) and production processes (e.g. Industry 4.0[1]);
- the 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 (GVCs), including positive effects in terms of growth, know-how and best practices. A related topic is that of design: companies that are able to develop original components, say, electric cars, can upgrade their position in the GVC towards the higher-value-added markets and increase their competitive advantage;

[1] Industry 4.0 or the Fourth Industrial Revolution refers to the ongoing automation of traditional manufacturing and industrial practices, using modern smart technology. For more information, see Glossary.

- the complexity of 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, leading 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 the customisation of products, leading 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, are now becoming relevant in relation to the public perception of autonomous driving cars;
- environmental impact: there is increasing concern regarding corporate environmental responsibility and the introduction of numerous public policies to control car pollution;
- privacy concerns: in an 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 companies have experienced various immediate problems due to the pandemic, in the long term the shock may lead to positive effects, in that it has 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). The Covid crisis has also accelerated the introduction of digital technologies and automation, as well as the implementation of further procedures regarding occupational health and safety at work in the pursuit of preventing contamination.

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) have all recently seen a relatively large number of patents being filed, indicating that these technologies are likely to grow in the future. The more comprehensive list of technologies increasingly coming on stream (see below) 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 form objects of developing innovative solutions (e.g. wheel systems, mechanical power transmission, door systems). These technologies are:

- data processing
- mechanical power transmission
- wheel systems
- internal combustion engines
- sensor control systems
- door systems
- materials
- seat systems
- load-carrying vehicles
- structural parts
- suspension systems
- 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 and cleaning.

From technologies to skill needs

The capacity of the automotive sector to obtain the maximum benefit from new technologies depends on the availability of the skills required 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 containing detailed information on the skills which comprise individual 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 incipient (future) jobs or new skill needs, another source – Wikipedia – was used to look for 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 competences within those jobs which are attached to various technologies. The jobs that 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, e.g. user interface developers, industrial mobile devices software developers, ICT system developers or ICT network engineers;
- technicians and associate professionals, such as robotics engineering technicians, industrial robot controllers and motor vehicle engine testers;
- skilled blue- and grey-collar workers, e.g. 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 the interviews often indicated that having a mentality that is more open to change will become increasingly necessary for people working in sales and management jobs in the 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 they presently do in order to accommodate the introduction of new technologies. The study also highlights the importance of what have been called 'grey-collar' workers – the category in between blue- and white-collar workers, and sometimes referred to as technicians in other countries. The importance of grey-collar workers implies the upskilling of existing blue-collar employees, indicating that higher levels of edification and training may be required for post holders to be fully competent in these jobs. It also suggests a shift in occupational structures towards more people being employed in medium- and high-skilled jobs, and much fewer in low-skilled positions.

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 broad spectrum of areas where skills will need to be acquired to master the use of various technologies (e.g. in relation to the use of a wide range of sensors). 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 the automotive industry, such as welders. While the traditional skills of welders range from knowledge of basic welding equipment and common welding techniques up to visual inspection competences, the interviews with key stakeholders and employers revealed that welders must now possess a wider knowledge base, including, for example, a deeper understanding of material properties, a higher digital capability, and the ability to speak fluent English.

Relatively few occupations show signs of obsolescence. Data mining analysis and interviews with companies seem to reveal that, even if digitalisation is disruptively changing the sector and some activities will be replaced 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 these jobs will be trained in new competences to take on more highly skilled roles.

To sum up, the evidence indicates that the majority of new workers will need to possess a wider range of skills than hitherto (marking a shift from low- to medium-skilled jobs). In particular, the interviews with companies pointed to the increasing relevance of multidisciplinary 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 employees demonstrating deep knowledge in various different vertical areas.

Responding to change: the views of stakeholders

In addition to desk research and data mining, interviews were held with key stakeholders and companies to understand the perspectives of those connected with the automotive sector, their views on emerging skills needs, and their experience so far of finding workers with these skills. The interviews revealed various conclusions.

- All the sector representatives confirmed the results of data mining and recognised that the sector is undergoing a period of advanced technological change, as outlined by the big data analysis. The findings from the interviews were aligned with the text-mining results, and indeed complemented them with further insights. They were also fully consistent with the results of other existing research on the Turkish manufacturing industry.
- Most companies indicated that the lack of skilled workers in the automotive sector was the main limiting factor to business growth. They noted shortages of white-collar workers with technology-specific competences – in particular those required by digital and ICT professionals – and of grey-collar workers (i.e. with skills levels between medium and high). Companies also pointed out that the education system is producing workers with gaps in their knowledge base. University graduates, for example, are limited in terms of 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 (i) a general mismatch between what is expected by companies and what is offered by the educational system; and (ii) the relatively low attractiveness of the automotive sector compared with other sectors for some profiles (e.g. ICT and data-related positions), as well as the fact that many highly skilled workers (including engineers) leave the country to work abroad. Retaining highly skilled talent is becoming more difficult than recruiting such employees.
- Many of the firms in the sector are indeed actively engaged in training their workforce (upskilling and re-skilling) in order to meet their current and future skill needs. It is relatively common for big firms to create their own training academies, while medium- and smaller-sized firms often provide on-the-job training and mentoring after recruitment, in addition to organising particular internal/ external courses led by more specialised staff. In certain cases, the training is aimed at imparting more practical knowledge, in others at introducing new technologies or upskilling blue-collar

workers to cover grey-collar roles. Having more detailed information on the skills needed helps companies to adapt, and may well contribute to stimulating the supply of highly sought-after skills.

- According to the respondents, universities and vocational education and training (VET) providers in Turkey are often insufficiently knowledgeable about the realities of the sector and changing skills demands – but this tends to be a common complaint across Europe. The findings from this study indicate the need for encouraging and pursuing a further, closer collaboration between business (companies) and education systems (both VET and higher education). The establishment of sector-based taskforces and skills partnerships among the main stakeholders could be helpful.

Improving skills anticipation

The use of a mixed methodological approach – combining desk research, data analysis and data-mining techniques, and interviews with stakeholders and companies – provided more nuanced information on emerging skills needs. This research thus identified the key technologies that drive skills demand over the short to medium term, and the range of occupations that will be most affected by technological change. Particular attention has been given to specific technologies shaping the skills needs within certain occupations and the new skills which are currently not included in the existing occupational classifications. The results can guide the future directions of training provision so that skill shortages which might constrain growth can be avoided.

This is not the end of the process. The report raises questions for further research; for example, information is required regarding the supply of skills (their quality and volume) and the scale of demand, on whether that demand is likely to be met, and the impact of unmet skills on the sector and the economy, as well as how the supply side should respond and how training providers can be supported to deliver the expertise needed by the automotive sector and thereby reduce any skills shortages or 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 skills forecasting and foresight exercises, as well as into the design of employer skills surveys. The latter can help identify the volume of demand for specific occupations, and the actual combinations of skills which are required within those jobs. They can also provide an indication of whether supply is keeping pace with demand.

Given the high speed of technological advances in sectors such as the automotive industry, it is periodically necessary to 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 these might be met. In this way the actors in the automotive sector will be better placed to proactively respond to the changes which are affecting the demand for skills.

1. INTRODUCTION

This report presents the results of first ETF case study on the future of skills in the automotive sector in Turkey (for other sectors, see ETF, 2020a; 2021a; 2021b). Conducted between January and December 2020, the study analyses how various drivers of change have affected and will continue to affect jobs and skill needs in this sector. The results reveal the changing skills demands in the automotive industry, and it is hoped that the study will stimulate debate among policy makers, practitioners and researchers on how to best adapt education and training provision in the light of this information.

The report is organised as follows. Chapter 2 sets out the analytical framework of the study and outlines the key steps of the methodological approach – although a detailed Methodological Note for conducting case studies is published separately (ETF, 2021c). This is followed, in Chapter 3, by an overview of the automotive sector in Turkey and its employment potential and occupational structure based on a literature review and a secondary analysis of official employment statistics (labour force survey). Readers are thus provided with the contextual background to the sector before delving into the details of the big data analysis and company interviews.

Chapter 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, with a focus on 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, Chapter 5 provides information on emerging skills needs and their impact on occupational job profiles. Chapter 6 outlines how the companies under review have responded to observed changes and met their emerging skill needs, including their strategies with regard to education and training providers and research centres. The chapter ends with a final word on the findings.

The report also includes a list of key stakeholder institutions in Turkey that were consulted and/or interviewed for the study (Annex 1), a list of the occupational standards and vocational qualifications applicable to the automotive sector (Annex 2), a glossary to set standard definitions for the labour-related concepts and explain some technical terminology, and a detailed bibliography.

2. METHODOLOGICAL APPROACH

The overarching goals of this study are to understand the drivers of change affecting the automotive sector in Turkey, ascertain the technological changes which are either taking place or about to occur, and identify the resulting skill needs. The study aims to reach an understanding of the links between technological change and skills demand so that policy makers can better respond to emerging sector needs. The initial research questions which provided the framework of the study are shown in Box 2.1.

BOX 2.1 SPECIFIC RESEARCH QUESTIONS

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, exports)?
2. What are the main drivers of change currently shaping the sector (e.g. trade, global value chains, new technologies, digital tools, 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, business practices, and labour and skills utilisation?
5. What are the main occupational profiles employed in the sector? Has the content of some occupations evolved as a result of the above changes in the sector – in what ways?
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 can be observed in the profiles of new recruits and in the published job vacancies?
8. What impact are these changes having on labour and skills demands in the sector? Are workers required to have higher levels of the same skills or completely new sets of skills?
9. How do these changes affect ‘skills utilisation’ and working conditions in the sector (e.g. in terms of salary, contracts, working hours, formality)?
10. How do businesses meet their needs for new skills (e.g. new hiring, retraining, etc.)? Are there examples of companies developing initiatives or cooperative links with education and training providers?

Questions about policy implications

11. Do technology, innovation and other changes push countries towards achieving higher added value and integration in the global value chain? Are skills contributing to this shift? If so, how?
12. Are any spillover effects from the changes discernible in the broader overall sector? What context-specific and general lessons can be derived from these studies?

Note: The last two questions were the most difficult to answer since none of the respondents provided any significant insights which could be used in the analysis.

The term ‘automotive’ here is intended to embrace a wide definition of the sector: first, it includes all motorised vehicles meant for transport on the 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, as well as vehicle traders (in the sales and aftersales market). From the occupational point of view, the focus has been on all job profiles and competences that may be affected by technological changes, regardless of the skills levels or tasks evident in the various companies. In summary, the study encompassed the sector’s overall value chain: the entire production process as well as sales and services – including the changes to be made in vehicle manufacturing systems, and the role of new entrants to the industry (e.g. Tesla), the supply-chain (e.g. those providing software to control vehicle performance) and new business models which differ from their predecessors in terms of the types of activities engaged in.

Given the need to be forward looking, a mixed methodological approach was used – combining desk research and data analysis with data-mining techniques and interviews with stakeholders and companies (Box 2.2).

BOX 2.2 STEPS FOLLOWED IN THE STUDY’S MIXED METHODOLOGICAL APPROACH

1. Well-established methodologies derived from social science, including:
   - a literature review of the automotive sector in Turkey,
   - a secondary analysis of employment and skills data, particularly focused on the sector.
2. Big data analysis in relation to the automotive sector in Turkey:
   - text-mining applied to a large number of documents, such as patents or scientific papers connected to the automotive industry, in order to identify the technologies impacting on the sector (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.

Note: For more information, see ETF (2021c).

The first step of the study was a review of the literature on innovation, employment and the skills pool generally in Turkey, followed by a description of the key features of the country’s automotive sector, its innovation and employment capacity, and its skills needs in particular. Based on data provided by Eurostat and Turkstat, it was possible to carry out some estimates of the workforce in the automotive sector, including its magnitude and changes over time in terms of occupational groups, qualifications and skills demands. This contextual analysis demonstrates that the capacity of the automotive sector

[2] ESCO – European multilingual classification of Skills, Competences and Occupations; for more information, see the Glossary at the end of the report and https://ec.europa.eu/esco/portal/home

[3] O*NET – Occupational Information Network – is a free online database of occupational requirements and worker attributes in the US economy. For more information, see the Glossary at the end of the report and www.onetonline.org/

to introduce the latest technologies rests not only on skills policies, but also on obtaining investment capital, forging links with research institutes, enlarging the internal market and offering relatively good jobs to attract those with the 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 generated 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 to conduct a manual search. And even if this were to be attempted, 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 times that particular technologies (or other relevant entities such as occupations, country names, etc.) are mentioned, as well as keeping track of all the interrelationships between key terms.

The principal sources used for the text-mining analysis were patents and scientific papers written in English. These sources form a large and accessible body of structured data, which is extremely important for the reliability and completeness of results. Patents are widely considered to be a good proxy for measuring innovation and anticipating technological changes (Terragno, 1979), while papers and conference proceedings also enable the study of 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, this database contains over 120 million documents from around the world and is updated daily (Kütt and Schmiemann, 1998). 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 internet using standard queries and downloaded for analysis[4].

These data were processed with proprietary algorithms to harmonise the names of inventors, authors, companies and universities, and to consolidate their geo-localisation according to NUTS codes (for a country-specific focus). Two types of patents were selected in our study: those issued directly by the Turkish Patent Office, and international patents for which at least one of the assignees was based in Turkey. Papers were selected if Turkey was cited among the countries of interest for the study. Erre Quadro's semantic algorithms were able to recognise functional concepts rather than simple keywords, and so they were used to scan the full text of each document to identify those with a focus on 'automotive'. Documents written since 1945 were retrieved, but for many analyses only the last twenty years of data were used. This represents a good window within which to spot temporal trends.

The 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. The next phase was to compare and match this information with the associated occupations and skills listed in the databases of ESCO and O*NET, using semantic matching algorithms[5]. The entire procedure was

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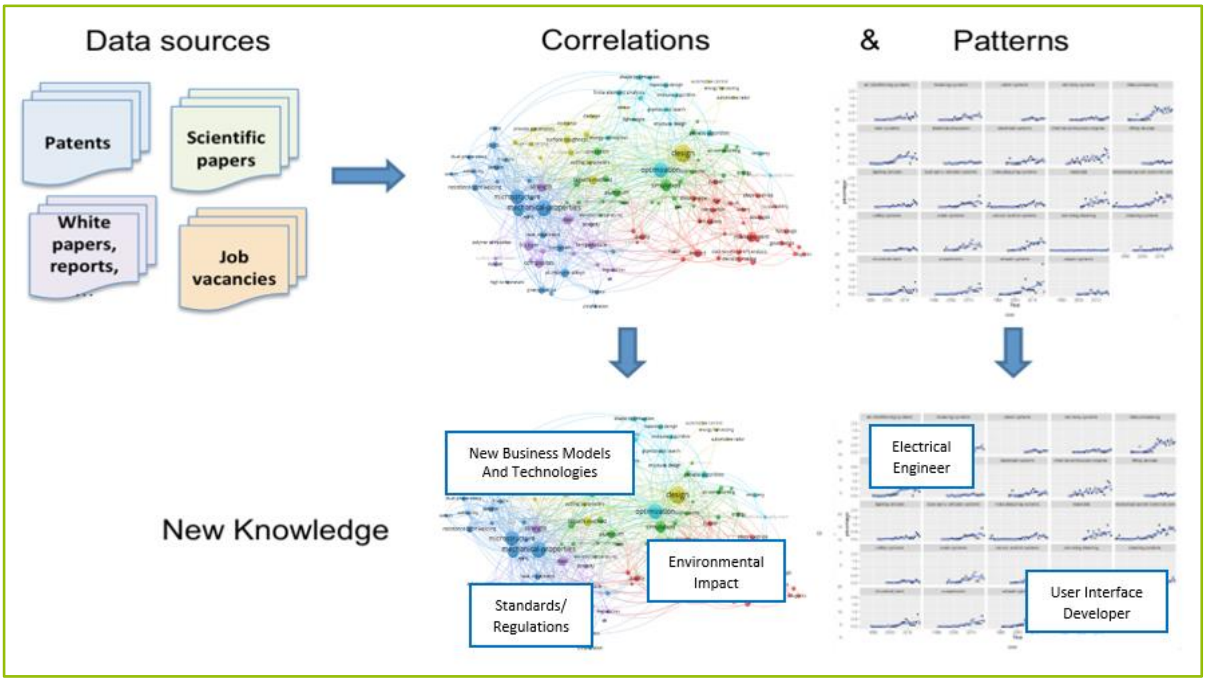
[4] However, these web pages were much fewer in number, unstructured and sometimes promotional in nature, and so less relevant than patents and papers.

[5] Erre Quadro's semantic algorithms are also able to find semantic connections between different concepts based on contextual information. For example, each occupation in the ESCO database includes a description

automated using ESCO's Application Programming Interface (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 an attempt to identify them.

The main advantage of text mining is the ability to search a very large number of documents quickly in real time. Patents and scientific papers in particular are structured and easy to access (compared to social media). Although information may be scattered over many different documents, algorithms are able to discover hidden patterns and emerging phenomena which might not be detected using manual search techniques. Moreover, correlating concepts and extracting trends allow weak signals to be detected and emerging trends to be spotted (see Figure 2.1). This gives a future-oriented perspective and hints at trends which cannot be inferred from past experience[6]. Thus the results of text mining include a variety of disruptive factors which can be further 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



and a list of competences, skills and knowledge considered relevant (either essential or optional) for that occupation. The semantic algorithm looks for matches for each technology with all the concepts associated with that occupation. When a match is found, the occupation is considered to be associated with the technology.

6 Anticipating the future from the extrapolation of past trends, even with the most sophisticated forecasting models, is likely to fail if the topic of analysis is subjected to rapid and disruptive changes. The most recent examples of such changes at the global level have been the 2008 global financial crisis and the Covid-19 pandemic.

The third step consisted of complementary qualitative research undertaken to obtain information from and gather the experiences of key stakeholders and companies in the sector concerning technological changes, other change drivers and new skill needs. Key stakeholders included the biggest sector associations in the automotive sector[7] as well as state institutions from both the labour and education and training sides. Due to the Covid-19 pandemic, two online focus group discussions were convened in May 2020 comprising all relevant stakeholders from the automotive sector (including public, private, academic and civil society organisations), covering not only economic actors but also those from the fields of employment and education. In total more than 55 representatives attended the focus group discussions. The purpose was to reflect upon the results from the previous steps. A full list of key stakeholders and companies who participated in the online focus groups is provided in Annex 1 – without the names of individuals for data privacy reasons.

After the focus groups, in-depth online interviews were conducted between June and October 2020. A semi-structured interview technique was used to guide the discussions. The main target group was companies from the sector that had filed the highest numbers of patents in recent years, and the questions focused on understanding their perceptions of and actions in adapting to and managing the technological change process within their companies and how they find the skills they need. The text mining from patents allowed the researchers to identify the top five innovative Turkish companies (as measured by the highest number of patents filed in recent years) for each technological cluster or sub-sector which emerged during the analysis. The companies which represented 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 the identification of around 30 Turkish companies. This list was also cross-checked for the 10 most active companies overall (i.e. not distinguishing by sub-sector when counting patents filed), since companies which are transversally innovative over different sub-sectors are surely of interest. It was then manually revised to check for duplicates or for mergers and acquisitions and to maintain a variety of sub-sectors. Finally reviewed by national experts, this resulted in 48 companies contacted.

In total 20 companies from the sector were interviewed, 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 (managers, R&D heads, human resources specialists) 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), as well as the impact upon the content of jobs and the related skills needs emerging from these changes. In addition, further interviews were conducted with the key sector associations specified above in footnote 7, and the few training providers in the sector.

Collecting the views of major stakeholders and interviewing representatives from the identified innovative companies helped to reveal the new skills demands linked to emerging technologies required at ground level by businesses. Although these companies do not necessarily represent the whole sector, the interviews provided first-hand evidence on managing technological changes and the resulting effect on employment and skills. Studying the segment at the frontier of innovation is key to shedding light on the changes that the other actors will have to follow. The focus of the study here was

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[7] The biggest and most important associations in the automotive sector are OSD (Turkish Automotive Manufacturers Association), TAYSAD (Turkish Automotive Suppliers' Association), ODD (Automotive Distributors' Association – both manufacturers and importers), and OYDER (Turkish Association of Authorised Automotive Dealers), covering both manufacturing and trading aspects.

on the changes in occupations and the skills necessary to perform these roles, not on the volume of skills demand. Overall, the interviews mostly confirmed the text-mining results and provided complementary information (no contradictions were apparent).

Combining different research methods brought advantages, as no single methodology could 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 steps were then compared, verified and confirmed. While direct interviews better captured the companies' product marketing and skills strategies, data mining clarified the technologies that are transforming or about to transform products and processes of which companies might simply be unaware. Nevertheless, there are certain limitations inherent in 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 interviews in the study. Future studies could include more interviews, with a more representative selection of companies and stakeholders; but this could prove resource-intensive and costly.
- The text mining was limited to searches in English; Turkish could not be used. However, it is likely that most of the patents and scientific papers were 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 more broadly.
- Despite the mixed methodological approach, this report was not able to give an indication of the scale or volume of changes in jobs and employment (e.g. 'how many extra electrical engineers will be required'), 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 filed to protect an invention that is just about to come on stream). But it is possible that some innovations are not patented and patents are mainly linked to technological advances. Non-technological innovations (e.g. those related to business models) are also important; the review of scientific papers and interviews with companies and stakeholders were seen as the best tools to capture these.
- The analysis of skills was limited to those which are associated with technologies and other trends identified by the text mining. If a certain technology was linked to occupations and skills at any level in the ESCO and O*NET databases, it was flagged. However, in cases where the association with a new technology had not yet been included, this had to be determined by interviews or other strategies.
- In the case of completely new (future) occupations and novel skill needs yet be included in the existing databases of ESCO or O*NET, other non-conventional data sources such as Wikipedia were used to access and identify such information. However, the material provided by these types of sources should be handled with care.

Whenever possible, these limitations have been partially compensated for by cross-checking results with existing similar studies published over the recent past. Findings and deliberations from other research studies have been analysed and considered to fill in the gaps and provide an overview of the sector in terms of skills needs and their evolution that is as exhaustive and 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 the skill content of jobs in the automotive sector to be identified along with possible changes in skills demands related to new technology. Thus, the focus is on actual jobs and how these will change over the short to medium term, rather than the broad aggregations of jobs into occupations. Data is captured on specific skills in particular jobs rather than with respect to the 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 introduced a high degree of uncertainty regarding the future of employment and skills demands. As the study is concerned with the long-term development of skill demands resulting from technological change, the findings are less sensitive to changes over the shorter term that have 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 supply chains disrupted by Covid-19 pandemic and the sector's high dependency on importing supply from overseas (i.e. raw materials, components and spare parts), as well as the need for not relying too heavily on manual labour.

It would not be surprising to see some countries or multinational companies re-shore automotive production from low-cost regions to higher-cost domestic markets (so-called 'deglobalisation') in order 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 to develop a more localised manufacturing base. Finally, this shift to more localised production could constitute a competitive advantage for Turkey, due mainly to its geographical proximity to the reference market for this sector, i.e. the EU.

3. OVERVIEW OF THE AUTOMOTIVE SECTOR

KEY ISSUES

- 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 skills demand in the automotive sector

This chapter provides an overview of recent developments in the Turkish economy and how this has affected the overall demand for employment and skills, followed by a specific focus on the employment and skill developments in the Turkish automotive sector – both the manufacturing branch and the sales and aftersales services side. Using the NACE classification of economic activities as a guide, this report defines the sector as a combination of C-29 (Manufacture of motor vehicles, trailers and semi-trailers) and G-45 (Wholesale and retail trade and repair of motor vehicles and motorcycles).

3.1 The Turkish economy

Driven by policies which have concentrated on stimulating domestic demand, the Turkish economy has experienced relatively rapid growth over the last 40 years, and this has brought about the creation of a substantial number of jobs, especially in the service sector. Consequently, GDP per capita has more than doubled since the early 2000s, which has been sustained by the continuous flow of workers from (informal) agricultural labour towards industry and services. This trend has lifted many people out of poverty and moved the country into the upper middle-income economy category (World Bank, 2019b). Employment by broad economic sectors indicates the dominant role of services in the occupational landscape (almost 57% of total employment in 2019), followed by industry (25% including construction) and agriculture (18%).

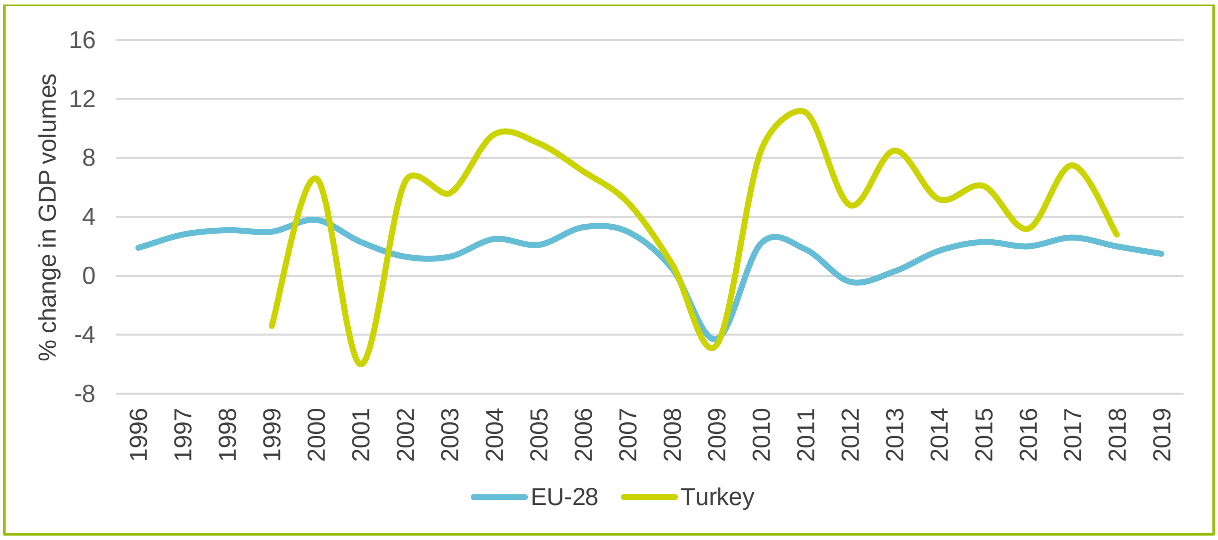
Turkey has an open economy. The World Bank Doing Business report ranks Turkey 43rd out of 190 economies and emphasises the positive impact of training on the operation of business (World Bank, 2019a). In 2017, Turkey exported goods and services worth USD 166 billion, making it the 27th largest exporter in the world. At the same time, its imports amounted to USD 214 billion, making it the 20th largest global importer of goods and services. However, there is a continuous trade imbalance, which has placed pressure on the economy to improve its competitiveness (OEC, no date).

Despite the country's economic dynamism, growth has been erratic, with many fluctuations seen over the years (see Figure 3.1). The growth rate was 2.8% in 2018, 0.9% in 2019, and is estimated as 1.8% for 2020 due to the impact of Covid-19. Following the 2018/19 downturn – largely a result of the trade war with the USA – which revealed the country's vulnerability to external shocks, the overall macroeconomic picture is more vulnerable and uncertain, given rising inflation and unemployment, sharp currency depreciations, contracting investment and increased financial sector vulnerabilities. This has brought about an increased policy emphasis on long-term productivity growth, innovation and human capital development (OECD, 2018).

The medium- to long-term impact of Covid-19 pandemic remains to be seen, but early evidence indicated economic contraction. In May 2020 industrial production in Turkey was down by 19%

compared to one year earlier (Turkstat)[8]. A recent study by the World Bank (Demir Şeker et al., 2020) on the impact of the pandemic in Turkey found that only 10% of the labour force in Turkey can work from home. Employment vulnerability is highest among the textiles and apparel, accommodation and food, and leather sectors, while jobs in information and communications technology (ICT) and finance are the least vulnerable. It seems that, overall, around 7 million workers are at the risk of losing their jobs due to the economic impacts of Covid-19 (Demir Şeker et al., 2020).

FIGURE 3.1 PERCENTAGE CHANGE IN GDP GROWTH, 1996–2019



Source: Eurostat, GDP data.

A number of acknowledged weaknesses impact the Turkish economy and labour market.

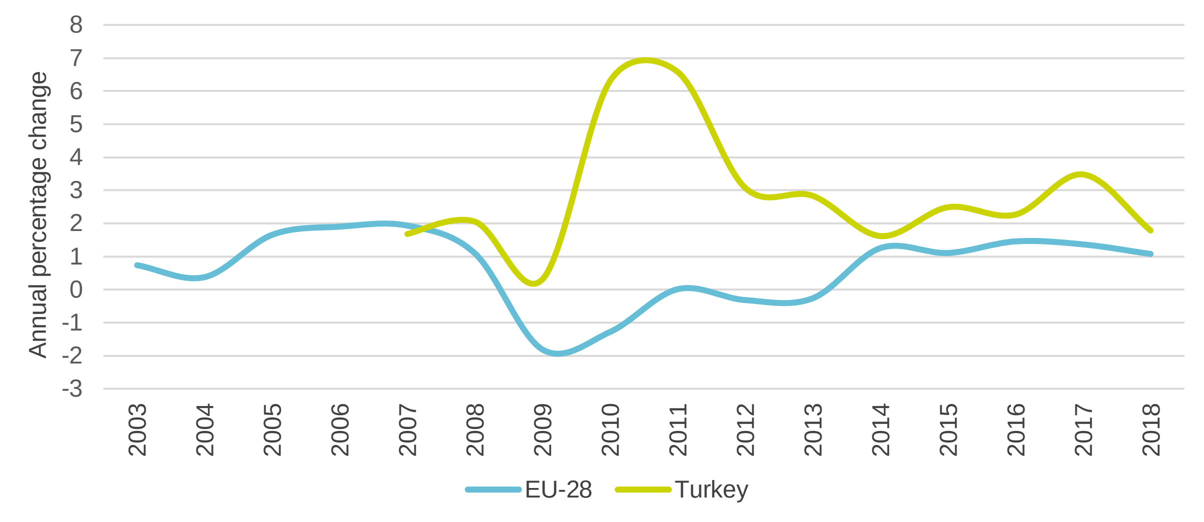
- There is a high level of informal and undeclared work in the economy which has been exacerbated by a large influx of Syrian refugees. In 2019 it was estimated that around 27% of the country's output emanated from the informal economy, while over a third of workers were employed informally (European Commission, 2019). The sizable informal economy is seen as drag on productivity in many economic studies (see e.g. Taymaz, 2009).
- A persistent geographical divide and wide regional disparities exist, especially between the 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 (MoNE, 2019; ETF, 2020b).

3.2 The Turkish labour market

Turkey has been able to create many jobs over the recent past, which has absorbed people moving out of the agricultural sector, and Figure 3.2 reveals that the country has consistently outperformed the EU in employment growth. An indication of the economy's development is found in the level of the national minimum wage. In 2015, it stood at EUR 424/month; a 59% increase from the figure of EUR 266/month registered in 2005 (Eurostat). However, due to recent devaluations of the Turkish lira, the national minimum wage returned back to its 2005 level in 2020.

[8] www.turkstat.gov.tr/PreHaberBultenleri.do?id=33800

FIGURE 3.2 ANNUAL PERCENTAGE GROWTH IN EMPLOYMENT, 2003–18



Source: Eurostat, Labour Force Survey.

Although the economy has developed substantially over recent years, 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. Moreover, the capacity of the labour market to absorb future growth is reinforced by demographic trends. The population in Turkey has been increasing by more than 1 million people a year since 2013. Characterised by its youth, half of the population was under 32 years old in 2017 (Eurostat). Population growth has also been boosted by the inflow of refugees from neighbouring Syria – more than 3.6 million people have fled to Turkey since 2015 (UNHCR).

The above points to spare capacity in the labour market to meet the demands of future growth. However, in terms of gender, the position of women in the labour market is especially disadvantaged, with significant gender and age gaps evident with respect to participation in the labour market (see Table 3.1). While the country's activity and employment rates have increased over time, they remain far below the EU-28 average, especially for women. For example, in 2019 the labour force participation rate was 58% in Turkey, compared to the EU-28 average of 74%. This is mainly due to women's low rate of economic activity in the labour market, with a gap of 40 percentage points between men and women seen in 2019 (78% as against 38%). This gender gap has not decreased over the decades, and the employment rates for women are less than half those of men. Improvement in women's activity rates has been accompanied by increased levels of female unemployment. Thus, the Turkish labour market does not use a large stock of its potential labour pool and available skills.

Overall, the employment situation of young people appears to have deteriorated over the period between 2010 and 2019, with an increase in young people not in education, employment or training (NEET) rates and a fall in the employment rate for recent graduates (Table 3.1). The same large gender gap exists even among the youth population, with women more likely to be NEET (34%) than men (18%). It is apparent that the deteriorating position of young people in the labour market and youth-related challenges have implications for the future skills supply in the country (ETF, 2020d).

TABLE 3.1 SUMMARY STATISTICS ON EMPLOYMENT IN TURKEY AND THE EU (20–64 AGE GROUP)

	Turkey			EU-28		
	2010	**2019**	**% change**	**2010**	**2019**	**% change**
Population size (million and percentage change)	72.6m	82m	+13	503.2m	513.5m	+2
Population aged 34 years and under (%)	60.3	54.5	-5.8	41.2	38.8	-2.4
Labour force participation rate – total	51.9	58.4	+6.5	71	74	+3
- Men	74.5	78.1	+3.6	77.6	79.4	+1.8
- Women	29.6	38.7	+9.1	64.6	68.6	+4
Employment rate – total	46.3	50.3	+4	64.1	69.2	+5.1
- Men	66.7	68.3	+1.6	70	74.4	+4.4
- Women	26.2	32.2	+6	58.2	64.1	+5.9
Unemployment rate – total	10.9	14	+3.1	9.7	6.4	-3.3
- Men	10.6	12.6	+2	9.7	6.2	-3.5
- Women	11.7	16.7	+5	9.7	6.7	-3
Youth unemployment rate	19.2	25.2	+6	21.4	15.1	-6.3
	2015	**2019**	**% change**	**2015**	**2019**	**% change**
Employment rate of recent graduates (% aged 20–34)						
- Graduates of ISCED 3–8	61.9	57.8	-4.1	75.5	80.9	+5.4
- ISCED 3–4 general programmes	47.4	44.3	-3.1	58.7	62.8	+4.1
- ISCED 3–4 vocational programmes	59.3	50.6	-8.7	72.3	79.1	+6.8
NEET rates (% aged 15–24) – total	23.9	26	+2.1	12.2	10.1	-2.1
- Men	14.1	18.3	+4.2	12.1	9.8	-2.3
- Women	33.7	34	+0.3	12.3	10.4	-1.9

Note: ISCED – International Standard Classification of Education
Source: Eurostat and ETF (2020c).

3.3 The skills pool and education of the workforce

Skill proves to be a difficult concept to measure. Over recent years advances have been made in measuring an individual's competence in relation to specific skills such as those related to numeracy, literacy, ICT, etc., but if an overall measure of skill is required, recourse is usually made to occupations and educational attainment levels. Both are imperfect measures of skill but they do provide a summary of skills from the national perspective with respect to the types of job people carry out and the levels of educational attainment or qualifications held by people in the labour market. As such, they are commonly used measures in statistical analyses of trends in the demand for skills. Therefore, this report analyses skills in terms of the occupations and educational attainment levels found in the labour force. When using education levels as a proxy for skills, the high-skilled are defined as those who have achieved ISCED 5 and above, the medium-skilled are those with ISCED 3 and 4, and the low-skilled are those with ISCED 2 and below.

According to the Human Capital Index developed by the World Bank, a child born in Turkey today will typically be 65% as productive when she grows up as she could be if she enjoyed a complete education and full health. The expected years of schooling currently stand at 12.1 years, while the learning-adjusted figure falls to 9.2 years when factoring in what children actually learn (World Bank, 2020). Table 3.2 shows enrolment rates in Turkey and the EU-28 respectively. An important point to make from this data is the high proportion of early school leavers in Turkey (almost 29% in 2019, compared to 11% in EU-28). Despite its downward trajectory (from 43.1% in 2010 to 28.7% in 2019), the large number of early leavers is the biggest challenge for the future labour market. Another aspect is participation in lifelong learning, which, although it has also improved over time, is roughly half of the current EU-28 average (ETF, 2019b).

TABLE 3.2 SUMMARY STATISTICS ON EDUCATION AND TRAINING IN TURKEY AND THE EU, 2019 (%)

	Turkey	EU-28 average
Net enrolment rate in upper secondary education	83.0 (2018)	95
Enrolment rates in VET (% of upper secondary enrolments)	46.0	48.4
Gross enrolment ratio in tertiary education (more than one-third in distance education programmes)	31.7 (2014)	70.9
Early school leavers (aged 18–24) – total	28.7	10.2
Participation in lifelong learning (last four weeks)	5.7	10.8

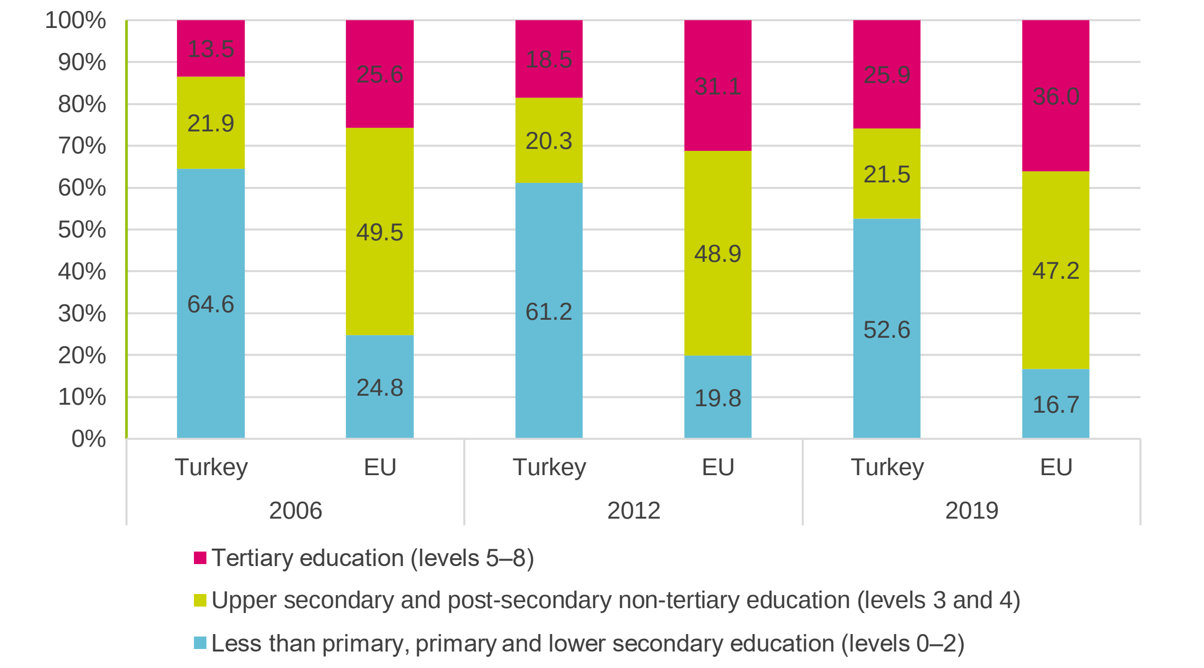
Source: Eurostat and ETF (2020c).

According to OECD (2019), Turkey faces significant skills challenges. These mostly stem from traditionally large numbers of early school leavers, often linked to rural living, gender and impoverished family backgrounds. As a result, the average skills outcomes of young people, tertiary graduates and adults are predominantly low. Levels of upper secondary attainment in Turkey are among the lowest of the OECD countries, with Turkish adults exhibiting significantly poorer proficiency in literacy, numeracy and problem-solving skills. Although the VET enrolment rate (% of upper secondary enrolments) is close to the EU average (46%), the quality and relevance of this school-based VET system remain weak. The Turkish education and training system needs to improve both the quality and accessibility of its provision for all students in order to ensure more inclusive and equitable skills development, as studies point to a stronger influence of young people's socio-economic background on their attainment of skills and tertiary education than in most other OECD countries (OECD, 2019).

Figure 3.3 shows that the educational attainment level of the employed population is higher in the EU than in Turkey. This is a clear indication of a higher skills demand in the EU economies compared to Turkey. Looking at the percentage of employed people with tertiary education, it is apparent that the gap between Turkey and the EU has remained constant over time. In 2006, the proportion of people in employment with a tertiary-level qualification was 26% in the EU and 14% in Turkey; a gap of 12 percentage points. By 2019, these figures were 36% in the EU and 26% in Turkey; a gap of 10 percentage points. But the real gap is seen in the medium-level qualifications: while 47% of workers in the EU were educated to this level in 2019 and 17% had a low educational attainment, only

21% of Turkish workers were medium-educated and the majority (53%) were low-educated. Strangely, the share of medium-educated workers in Turkey is not increasing (ETF, 2020b), on the contrary, there has been a slight decrease, from 21.9% in 2006 to 21.5% in 2019.

FIGURE 3.3 EMPLOYED POPULATION AGED 15–64 BY EDUCATIONAL ATTAINMENT IN TURKEY AND THE EU, 2006, 2012 AND 2019

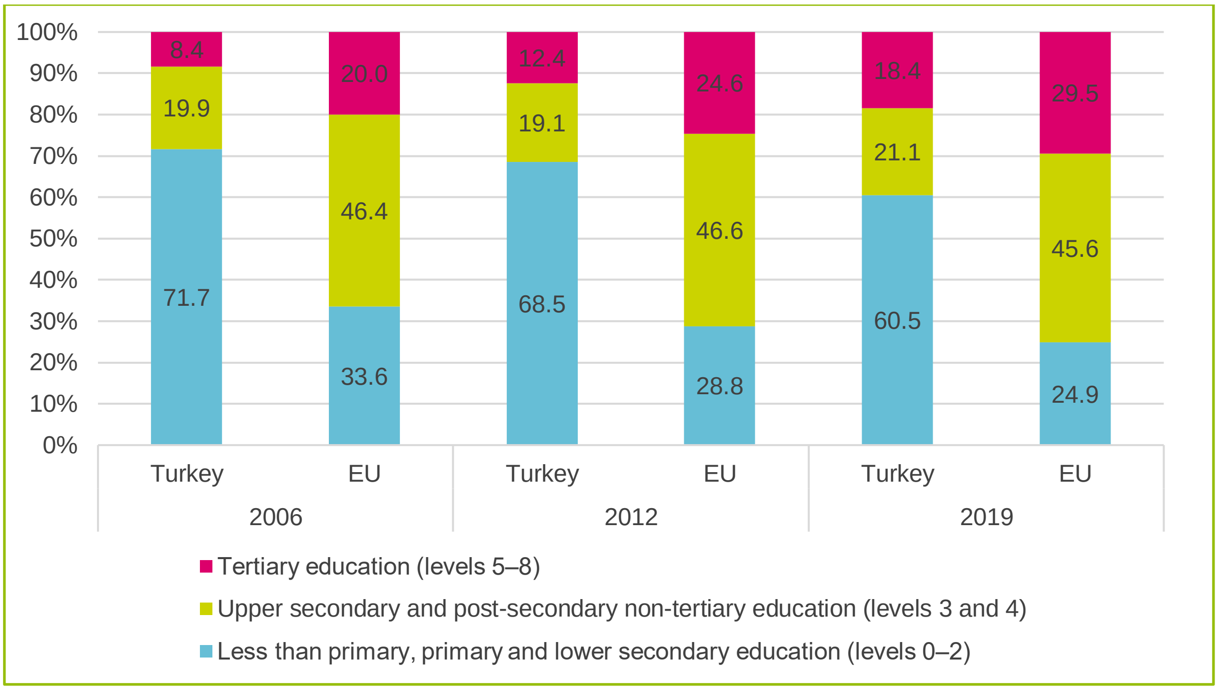


Source: Eurostat, Population by educational attainment level [edat_lfs_9902].

A similar result is seen if one looks at levels of educational attainment in the general population (Figure 3.4). The evidence shows 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 had a low level of educational attainment, 21% 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; while levels of educational attainment have increased over recent years in Turkey, they have also risen in the EU at more or less the same rate, and thus the attainment gap has remained relatively constant.

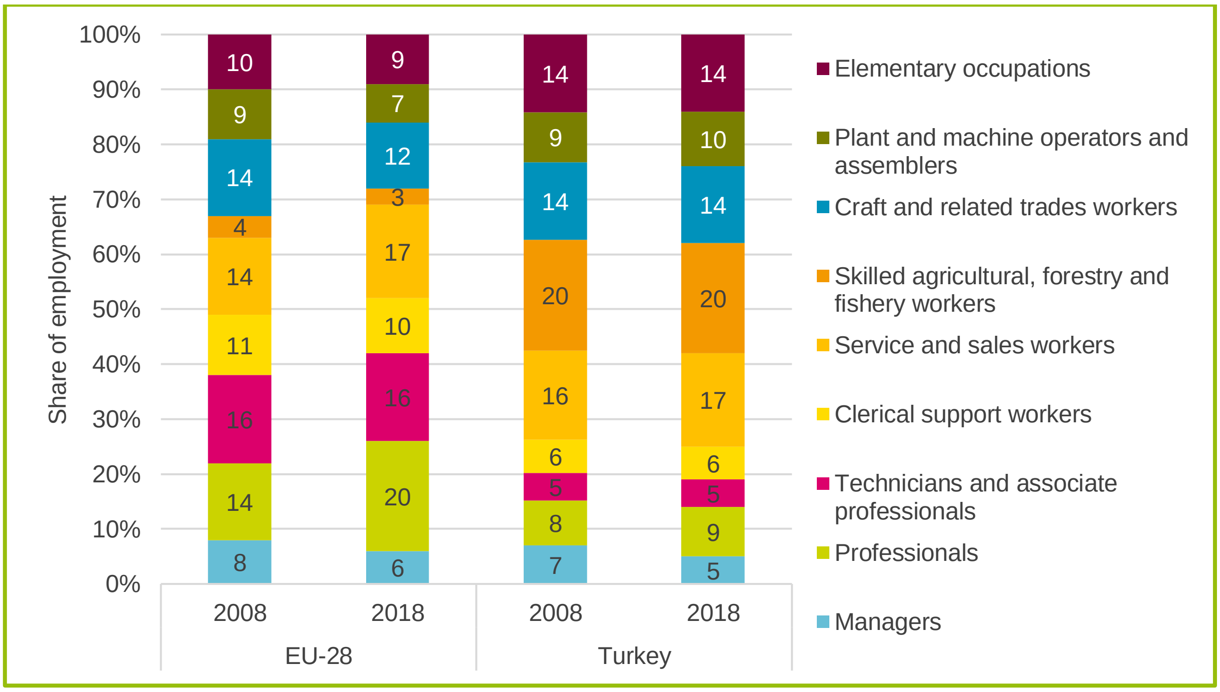
When occupational groups are used to identify skill levels, typically managers, professionals and associate professionals are counted as high-skilled occupations, while elementary occupations are considered low-skilled positions. Figure 3.5 shows that the percentage of people in high-skilled jobs in Turkey is relatively low compared with the EU-28 and has not increased over time. In the EU, the share of employed people in high-skilled occupations increased from 38% in 2008 to 42% in 2018, while in Turkey the proportion of workers in this group was much smaller and, in contrast to the EU, remained more or less stable over the same period (at around 20%). The share of employment in elementary occupations is higher in Turkey than in the EU and, again, has not decreased over time (accounting for 14% of total employment in 2008 and 2018). The lack of growth in high-skilled and medium-skilled occupations clearly has implications for the economy in its potential to stall productivity.

FIGURE 3.4 EDUCATIONAL ATTAINMENT LEVELS OF THE POPULATION AGED 15–64 IN TURKEY AND THE EU, 2006, 2012 AND 2019



Source: Eurostat, Population by educational attainment level [edat_lfse03].

FIGURE 3.5 EMPLOYMENT BY OCCUPATIONAL GROUP, 2008 AND 2018



Source: Eurostat, Labour Force Survey.

The above concerns outputs from the initial education and training system. Looking at participation in education and training in the last four weeks provides an indication of the extent to which people are engaged in continuing training. As the Eurostat LFS reveals, the participation of adults (aged 25–64) in lifelong learning activities in Turkey, at 5.7%, though increasing over time, is well below the EU-28 average of 10.8%. To some extent this reflects the comparatively high shares of people employed in relatively low-skilled employment. Results from the 2016 OECD Programme for the International Assessment of Adult Competencies (PIAAC) revealed below-average proficiency in literacy, numeracy and problem solving in technology-rich environments among the adult population in Turkey compared with the same cohort 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 (OECD, 2016).

Given the role of the automotive sector in the Turkish economy, it might be interesting to compare the educational attainment levels of Turkey's employed population with those of EU countries with sizable car industries, such as Germany, Spain and Slovakia (see Table 3.3). Among those qualified at the medium level (ISCED 3 and 4), Turkey's proportion of employed workers with this level of attainment is relatively low compared with the other countries (except Spain). Many automotive assembly line jobs typically require people to be educated to this level, often through taking an apprenticeship (medium-skilled). The Turkish economy instead largely depends on people with a basic level of education (i.e. ISCED 0–2), which may have negative implications for its capacity to adapt to future technological changes.

TABLE 3.3 EDUCATIONAL ATTAINMENT LEVELS OF THE EMPLOYED POPULATION AGED 15–64 IN 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 0–2)	52.6	12.6	32.2	4.4
Upper secondary and post-secondary non-tertiary education (ISCED 3 and 4)	21.5	57.7	24.0	68.3
Tertiary education (ISCED 5–8)	25.9	30.0	43.8	27.3

Source: Eurostat, Population by educational attainment level [edat_lfse03].

Although the gap at the tertiary level is less significant, it is highly conspicuous for medium-educated workers. Depending upon where future growth in employment takes place in the automotive sector, Turkey may be more or less disadvantaged with respect to meeting the demand for skills. As indicated in later sections – based on the big data analysis – there appears to be an increasing need for people with at least ISCED 3–4 level qualifications (and ISCED 5A). This potentially places increased pressure on the VET system in Turkey given the relatively low percentage of people currently qualified to this level compared with other countries.

The evidence tends to point to Turkey being in a state of low skills-equilibrium compared with the EU. The demand for higher skills is relatively low, but where the education system has sought to raise skills levels and skills supply has increased, it is apparent that the labour market has struggled to absorb those skills, resulting in mismatches. This seems to be essentially a problem of over-supply in terms of certain skills (World Bank, 2019b). There is also evidence of under-supply. Based on data from the jobs portal of the Turkish Employment Agency (IŞKUR) and the results of a 2019 employer survey, several of the jobs where demand outstrips supply (where the growth in job vacancies has been greater than the corresponding job placements) are of direct relevance to the automotive sector:

CNC operators[9]; sales consultants; electricians; industrial automation technicians; mechatronics technicians; hybrid vehicle experts; and automotive assembly line workers (IŞKUR, 2019). The most in-demand occupations tend to be principally intermediate (medium-skilled) jobs.

3.4 The Turkish automotive sector

This section provides a description of outputs, employment and skills in the automotive sector. In this report, the automotive sector covers both the manufacture and the trading of vehicles. Using the NACE classification of economic activities as a guide, the sector is defined as a combination of the groups C-29 (Manufacture of motor vehicles, trailers and semi-trailers) and G-45 (Wholesale and retail trade and repair of motor vehicles and motorcycles). Consequently, we adopted a wide definition of the sector, including the manufacture of all motorised vehicles meant for transport on the road, and their production processes (from assembly line to additive manufacturing), as well as incorporating all the actors of the value chain, from original manufacturers to suppliers of components and services, and taking in the trade of vehicles (the sales and aftersales market).

Given recent levels of output and employment growth, the automotive sector is an important driver of expansion in the Turkish economy, often creating relatively skilled and decent jobs. Between 2009 and 2019 output growth in the automotive sector, both in the manufacturing and sales segments, outstripped that recorded in the economy as a whole. The sector is well organised in terms of both its production as well as its distribution and trading segments. The 14 original equipment manufacturers (OEMs) are managed and represented by the Turkish Automotive Manufacturers' Association (OSD)[10]. The Turkish Automotive Suppliers' Association (TAYSAD), on the other hand, represents more than 460 companies which supply automotive parts for both domestic and international OEMs[11]. The next actor in the value chain is the Automotive Distributors' Association (ODD), which has 29 members representing 47 international brands (both Turkish automotive manufacturers and importers)[12]. Finally, the Turkish Association of Authorised Automotive Dealers (OYDER) represents around 1 200 automotive dealers (in retail trading), including sales, insurance and other 'after sales services', and 'spare-part sales'[13].

Table 3.4 shows the number of enterprises in the sector in 2019: 4 910 firms in the manufacturing branch and more than 162 000 firms on the trading side. As seen from the numbers, companies in the manufacturing segment are typically medium and large in size, while in wholesale and retail sales they are much smaller. Since 2009, the number of manufacturing firms has grown by almost 42%, and in trading by 55%. Given the total of more than 3.2 million firms operating in the country, those in the automotive sector consist of 5.2% of the total enterprises in Turkey – with the manufacturing part consisting of only 0.2% and the services/sales segment 5%.

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[9] CNC operator produces machined parts by programming, setting up and operating a computer numerical control (CNC) machine.

[10] See www.osd.org.tr/homepage

[11] Established in 1978, TAYSAD is the most important representative of the Turkish automotive supplier companies, representing 65% of the output of the automotive supplier industry and 70% of the industry's exports. See www.taysad.org.tr/en

[12] www.odd.org.tr/web_2837_2/index.aspx

[13] These automotive dealers sell 889 different types of vehicles from 47 international brands. See www.oyder-tr.org/authorized-automotive-dealers-association

TABLE 3.4 NUMBER OF ENTERPRISES IN THE TURKISH AUTOMOTIVE SECTOR (NACE C-29 AND G-45)

NACE economic sectors	2019
C-29 Manufacture of motor vehicles, trailers and semi-trailers	**4 910**
C-291 Manufacture of motor vehicles	62 (1.3%)
C-292 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	1 785 (36.3%)
C-293 Manufacture of parts and accessories for motor vehicles (including electrical and electronic equipment)	3 063 (62.4%)
G-45 Wholesale and retail trade and repair of motor vehicles and motorcycles	**162 361**
G-451 Sale of motor vehicles	33 863
G-452 Maintenance and repair of motor vehicles	93 788
G-453 Sale of motor vehicle parts and accessories	29 006
G-454 Sale, maintenance and repair of motorcycles and related parts and accessories	5 704
C-29 and G-45 together	**167 271**
Turkey total number of enterprises (all)	**3 228 421**

Source: Turkstat Annual Industry and Service Statistics, https://data.tuik.gov.tr/tr/main-category-sub-categories-sub-components2/#

There are substantial differences in the use of technologies and skills in the manufacturing and services/trading segments of the automotive sector. This has a significant impact on the type of workers employed in each segment, including their tasks and skills, educational attainment levels and the quality of jobs offered. Therefore, these aspects have to be taken into account when analysing the sector as a whole. A short overview of each segment of the sector is provided below.

Sub-sector C-29. Manufacture of motor vehicles, trailers and semi-trailers

The first major automotive plant in Turkey was established in 1956 when Otosan was licensed to produce Ford vehicles. Currently 14 OEMs operate in Turkey[14] with a total annual production of around 1.5 million vehicles (OSD, 2020). The majority of vehicles are produced in the north-west of Turkey, in the regions of Kocaeli, Sakarya and Bursa (OSD, 2018). The output of the Turkish automotive industry is very much in line with other European countries with developed car manufacturing industries, such as Czechia and Slovakia. Respectively, these countries produced 1.4 million and 1.1 million vehicles in 2019 (OICA, 2019). The key issue for the sector in Turkey is the future course of the product market trajectory – i.e. whether, for instance, it increasingly shifts away from production and into design and manufacture.

The main advantage of the sector is the existence of a large and strong automotive suppliers' segment, which is able produce high-quality outputs that can be used by the OEMs in both Turkey

[14] OEMs are the manufacturers of the original vehicle equipment, i.e. the parts assembled and installed during the construction of a new vehicle. In contrast, aftermarket parts are those made by companies other than OEMs, 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 and Tofaş. Toyota.Türk Traktör and Hattat Traktör are tractor manufacturers.

and Europe (ISO, 2002). The manufacturing part is also a highly formalised sector with high levels of formal employment, and generates some of the biggest tax revenues for the state. The jobs on this side are relatively 'good', with job security, full-time employment, continuous training and above-average salaries. The suppliers' side, on the other hand, includes many small companies that face a greater range of challenges, for example: unstable internal market conditions, large volumes of imported foreign automotive products, overproduction in times of high demand, and a complicated and extremely highly taxed system for regulating automotive products in the internal market.

The Turkish automotive sector is fully integrated into global value chains, which has contributed to higher productivity and faster economic growth (Ziemann and Guérard, 2016). In providing a channel for attracting foreign direct investment, transferring new technologies, and acquiring knowledge and know-how, spillover effects have been created in terms of jobs and skills, while the demand for skilled labour has increased (Taymaz and Yilmaz, 2008). As in other countries in the region, Turkey's economy and its automotive sector is strongly connected to the 'economic centre' of the EU through the trading of goods and services, foreign direct investment and labour migration (as well as by the EU-Turkey Association Agreement). This connection has been further strengthened since 1996 by the conclusion of the Customs Union between Turkey and the EU. This has enabled the manufacturing segment of the sector to export to European markets within the free trade area on the basis of low or zero tariffs.

Close economic relations with major economies in Europe (especially Germany, Italy and France) have also led the Turkish companies to follow the European technical standards, from safety rules to environmental regulations. Because the main suppliers of the Turkish automotive sector are based in Europe and most of its automotive products are sold there, Turkey closely follows European market trends, producing and selling hybrid vehicles and new cleaner models. Although Turkish consumers seem to be less conscious of environmental concerns compared to Europeans (as indicated in the interviews), the connection between the Turkish economy and trade to Europe ensures that the automotive supply trade in the country is more environmentally friendly. For example, Turkey has recently adopted the relevant EU regulations on carbon emissions (e.g. Euro 6).

Furthermore, Turkey's manufacturing companies are highly engaged in international markets, and automotive products play a very important role in global trade, having been the number one export item since 2006 (accounting for 17% of the total value of exports). The main destinations for automotive products are Germany (14%), France (12%), Italy (10%), the UK (8%) and Spain (6%) (Turkstat). Moreover, the manufacturing part of the sector contributes 4% to the country's GDP. In the last few years, the sector has exported around 85% of its total production (valued at USD 21.3 billion compared with USD 13.1 billion in 2015) (OSD, 2020). Passenger cars are the major exports (accounting for 829 000 units in 2019), although the number of total exports – and those of passenger cars in particular – has been slowly decreasing over recent years (OSD, 2020). In response to fierce international competition, the sector tends to drive up their skill demands as enterprises attempt to capture higher value segments of the global market (Mason, 2004).

Recently the Turkish state has also invested in a public-private partnership to develop and produce its own automotive brand, provisionally called TOGG. TOGG (or Turkey's Automobile Joint Venture

Group) is a Turkish automotive company founded as a joint venture in 2018[15]. It aims to produce two all-electric cars, with 300 km and 500 km range options. Both cars will have an eight-year battery warranty and level 2 autonomous driving assistance. The prototypes of the cars were unveiled in December 2019, and mass production is planned to start in 2023.

Sub-sector G-45. Wholesale and retail trade and repair of motor vehicles and motorcycles

There is a high potential for the retail car trade in the Turkish domestic market. The number of passenger cars per 1 000 people in Turkey was 193 in 2019, compared to 560 in Europe. Germany has 800 cars per 1 000 people (according to the interviews). As of September 2020, there was a total of around 23.8 million registered vehicles in Turkey (Turkstat). State policies on the sector (especially with regard to taxes on automobile sales) and economic fluctuations are the most important external factors affecting jobs in the trading segment. Sales in the sector are often unstable, with many ups and downs, depending on the general socio-economic conditions, the financial and economic situation of the country and the foreign exchange rate[16].

As the country's per capita income has increased, the demand for cars from Turkish consumers has also grown; especially for foreign-produced vehicles. In 2015, 73% of all passenger cars sold in Turkey were imported (mainly models by Volkswagen, Opel and Ford) (OBG, 2015). Thus the country 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 (OEC, 2017). Since 2019, as a result of temporary tax incentives offered to domestic automotive products, the share of imported vehicles has dropped to around 60%, but Turkish customers like to have wide range of options in terms of buying cars and this figure will rapidly increase following the cancellation of the tax incentives in 2020.

The country has a policy of heavy taxation on vehicle sales, which limits trade in the domestic market: automotive purchases incur a special consumption tax, ranging from 45 to 80% for engines up to 1.6 litres and rising to 130% for engines up to 2 litres and 240% for engines above 2.0 litres. VAT of 18% is then applied to the combined figure of the pre-tax price plus the special consumption tax. This means that the effective tax rate on the purchase of a car extends from 70% to 250% (as noted in the interviews). In addition, the low profit margins of the sector (4% in the best cases) further hamper the possibilities for investing. Currently there are no state tax incentives to buy more environmentally friendly cars (hybrid or electric) in the Turkish market, but financial inducements to buy electrical cars may be put in place in 2023 when the Turkish brand of electrical cars (TOGG) will come onto the market (as reported in the interviews).

The jobs in this sub-sector are not as good as in the manufacturing segment. Indeed, the retail sector has a high turnover (rotation) rate among sales workers; around 35% of employees change every year. This is also linked to low average wages, although employees earn a bonus for every car

[15] Turkey's Automobile Joint Venture Group (TOGG) includes the Anadolu Group, BMC Turkey, the Kök Group, Turkcell and Zorlu Holding as major stakeholders under the umbrella institution TOBB. Each company has a share of 19% and TOBB itself holds 5%. Italian car designer Pininfarina designed the car based on TOGG's requirements, while its battery cells will be produced by the Chinese company Farasis Energy.

[16] For example, in 2015, 2016 and 2017, on average, 1 million vehicles were sold annually. In 2018 after a small crisis, this figure fell to around 240 000. In 2019 after another crisis, sales were around 400 000 vehicles. In 2020, despite the bad economic situation followed by the Covid-19 pandemic, sales increased again to approximately 800 000, probably because many people did not want to use public transportation due to the risk of infection (as noted in the interviews).

they sell[17]. The Covid-19 pandemic has turned face-to-face sales into online sales, and there is now greater awareness of the importance of digitalisation and its impact on online sales. New sales strategies such as ‘rent a car’ and ‘operational leasing with companies’ are growing fast. Currently, leasing accounts for around 15% of total sales, but it is expected to expand rapidly, and may easily reach 25 or 30%. Car-sharing, on the other hand, is not popular in Turkey. Turkish customers are very interested in high-technology vehicles, and always want the latest equipment when they buy cars.

Employment and skills in the automotive sector

When it comes to the numbers employed in the Turkish automotive sector, they change significantly according to the source consulted[18]. Looking at the Turkstat Annual Industry and Service Statistics (as reported by enterprises), the number of waged employees in the whole automotive sector rose to 582 706 workers in 2019 (Table 3.5). Out of this figure, almost 32% of the workers were employed in the manufacturing segment (186 228), and the rest in the trading segment (396 478). Since 2009, the number of waged employees in the manufacturing segment has grown by 66%, and on the trade side by 62%. Considering that Turkey’s workforce numbers more than 28 million people, these figures imply a small automotive sector (2.07% of total employment) – with the manufacturing part consisting of only 0.7%.

TABLE 3.5 NUMBER OF WAGED EMPLOYEES IN THE TURKISH AUTOMOTIVE SECTOR (NACE C-29 AND G-45)

NACE economic sectors	2019	%
C-29 Manufacture of motor vehicles, trailers and semi-trailers	**186 228**	**31.9** of which:
C-291 Manufacture of motor vehicles	54 225	29.1
C-292 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	15 712	8.4
C-293 Manufacture of parts and accessories for motor vehicles (including electrical and electronic equipment)	116 291	62.5
G-45 Wholesale and retail trade and repair of motor vehicles and motorcycles	**396 478**	**68.1** of which:
G-451 Sale of motor vehicles	113 819	28.7
G-452 Maintenance and repair of motor vehicles	177 741	44.8
G-453 Sale of motor vehicle parts and accessories	95 485	24.1
G-454 Sale, maintenance and repair of motorcycles and related parts and accessories	9 433	2.4
C-29 and G-45 together (+64.0% increase of total employment since 2009)	**582 706**	**100**

Source: Turkstat Annual Industry and Service Statistics, https://data.tuik.gov.tr/tr/main-category-sub-categories-sub-components2/#

[17] The average basic wage is around TL 2 500 (about EUR 250), but with bonuses it is possible for a good salesperson to earn a relatively high salary. Normally, sales staff are employed on a full-time basis and are registered with the social security system. However, they do not have separate employment contracts, and this workforce is regarded as very flexible in terms of hiring and firing (according to the interviews).

[18] For example, when four sector representatives were asked, OSD reported that 50 000–52 000 people were employed in OEM factories (OSD, 2020); TAYSAD estimated that 250 000 workers were engaged in the production of spare parts for suppliers; OYDER reported around 70 000 people working in retail trading; and ODD noted that 3 500 workers were employed on the wholesale distribution side (as noted in the interviews). This adds up to more than 375 000 workers in waged employment for 2019.

However, this report uses LFS data as the main source of employment information as it is more comprehensive and captures the picture of employment in the sector most close to reality. The LFS is based on a nationally representative sample of household surveys, with individual responses recoded from members aged 15+ about their working life and sector. As such, it is the best data source for understanding the complete employment landscape in the automotive sector (including self-employment or other forms of working). Table 3.6 gives the LFS numbers for employment in the automotive sector and its sub-sectors for the years 2010 and 2019. As shown, a total of 812 000 people were employed in the automotive sector in 2019, comprising around 2.9% of total employment. Out of this, 33.6% were working in the manufacturing segment (273 000), constituting around 0.9% of total employment in Turkey.

TABLE 3.6 EMPLOYMENT IN THE AUTOMOTIVE SECTOR AND SUB-SECTORS, 2010–19

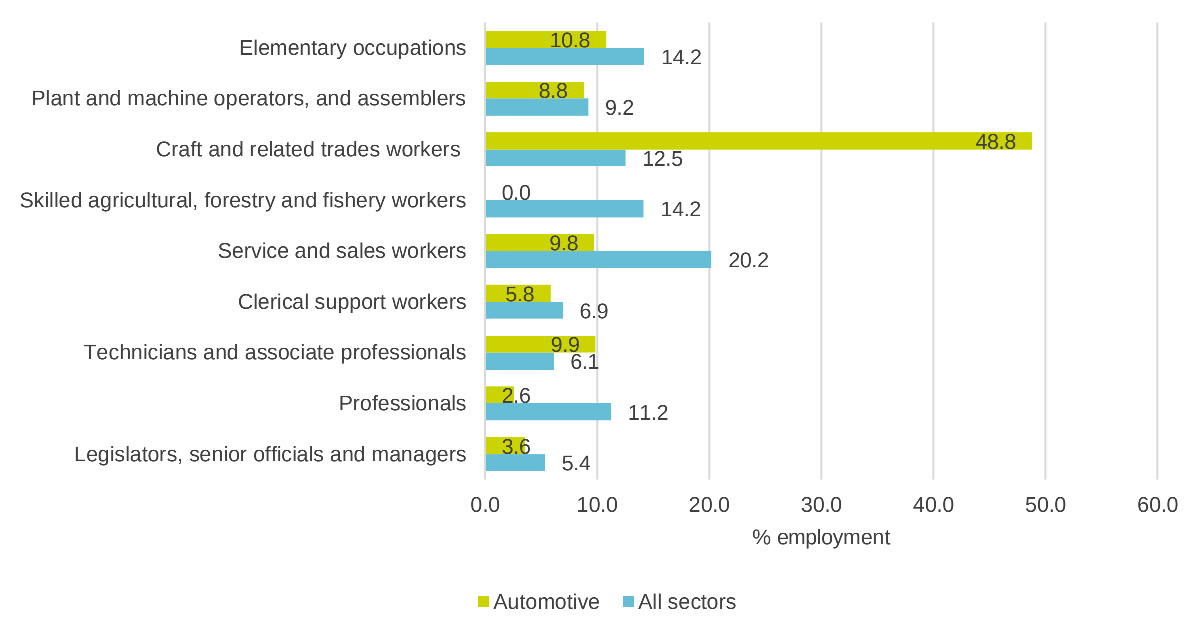
	2010	2019	Change	% change
Total employment in numbers	22 594 000	28 080 000	5 486 000	24.3
Employment in the automotive sector, of which:	601 000	812 000	211 000	35.1
- C-29 Manufacture of motor vehicles, trailers and semi-trailers	191 000	273 000	82 000	42.9
- G-45 Wholesale and retail trade and repair of motor vehicles motorcycles	410 000	539 000	129 000	31.4

Note: Since 2014 LFS has been implemented continuously in Turkey, but there was a series break in 2014. This led to the differentiation of the previous series of indicators and eliminated the data's comparability.
Source: Turkstat, based on the LFS datasets.

What is important to emphasise is the substantial increase in employment in the sector over recent years (see Table 3.6). The sector has grown very rapidly in the past ten years compared with employment across the economy as a whole. Indeed, employment in the manufacturing segment of the automotive sector has increased by almost 43% since 2009, compared with 31% in the trading division (both are higher increases than the 24% overall increase in total employment). This shows the employment potential of the sector, although we are still talking about less than 3% of the total employment in the country.

As discussed in Section 3.3, skills here refer to the occupational structure and educational attainment levels of employees in the automotive sector. Figure 3.6 compares the occupational structure of employment in the overall economy with that of the automotive sector in 2019 – both sub-sectors combined. It reveals that, compared with the overall economy, the automotive sector is relatively more dependent upon (i) technicians and associate professionals (10% here against 6% in total); and (ii) craft and related trade workers (49% in this sector versus 13% in total). Interestingly, the percentage of people employed in managerial, professional and associate professional occupations – the so-called higher-level occupations – is 16% in both branches of the automotive sector, slightly lower than the economy as a whole at 23%. Since 2010, there has been a small increase in the share of people employed in professional and associate professional jobs, and a slight fall in the proportion of those working as craft and related trades workers (Turkstat).

FIGURE 3.6 OCCUPATIONAL DISTRIBUTION OF EMPLOYMENT IN TURKEY: TOTAL VS AUTOMOTIVE, 2019



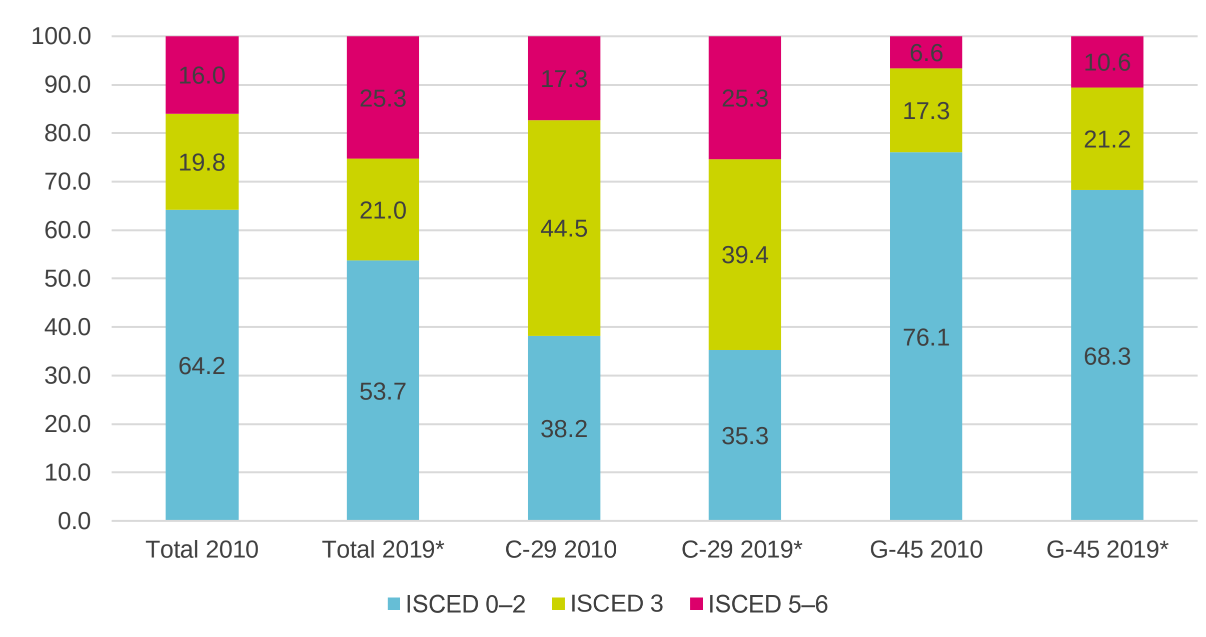
Note: Since 2014 LFS has been implemented continuously in Turkey, but there was a series break in 2014. This led to the differentiation of the previous series of indicators and eliminated the data's comparability.
Source: Turkstat, calculation from LFS datasets.

A further insight into labour demand in the automotive sector can be gained from looking at the age, gender and education levels of the current workforce in each segment of the industry. Combining both sub-sectors (C-29 and G-45) under one analysis and mixing the manufacturing and trading segments masks the large differences between the two fields. Indeed, LFS datasets provided for each sub-sector show that employees in the manufacturing segment (34%, 273 000) are often more highly skilled than employees in the trading area (66%, 539 000).

Figure 3.7 indicates the education levels of employees in total employment and the two sub-segments of automotive sector – the manufacturing and trading fields respectively[19]. In 2019 in the manufacturing segment (C-29), 25.3% of all employees were high-skilled, 39.4% were medium-skilled and 35.3% were low-skilled. This means that, in comparison with the rest of the economy, this sub-sector demands workers with much higher skill levels and the jobs here are of higher quality. Compared to the total employment profile, automotive manufacturing employs a significant share of medium-skilled workers and much fewer low-skilled workers. Moreover, since 2010, the proportion of high-skilled workers has increased substantially (from 17.3% to 25.3%), but there has been a 5 percentage points decrease in the share of medium-skilled workers. On the other hand, in the trading segment (G-45) in 2019 only 10.6% of all employees were high-skilled, 21.2% were medium-skilled and 68.3% were low-skilled. Thus, the education level in this sub-segment is very low, even lower than that of total employment – albeit with a slow improvement in all education levels since 2010 (see Figure 3.7, noting an 8 percentage points decrease in low-skilled workers).

[19] Education levels are classified as the high-skilled (ISCED 5–6), the medium-skilled (ISCED 3–4) and the low-skilled (ISCED 0–2).

FIGURE 3.7 EMPLOYMENT BY EDUCATIONAL ATTAINMENT LEVELS: TOTAL, C-29 AND G-45, 2010 AND 2019 (%)

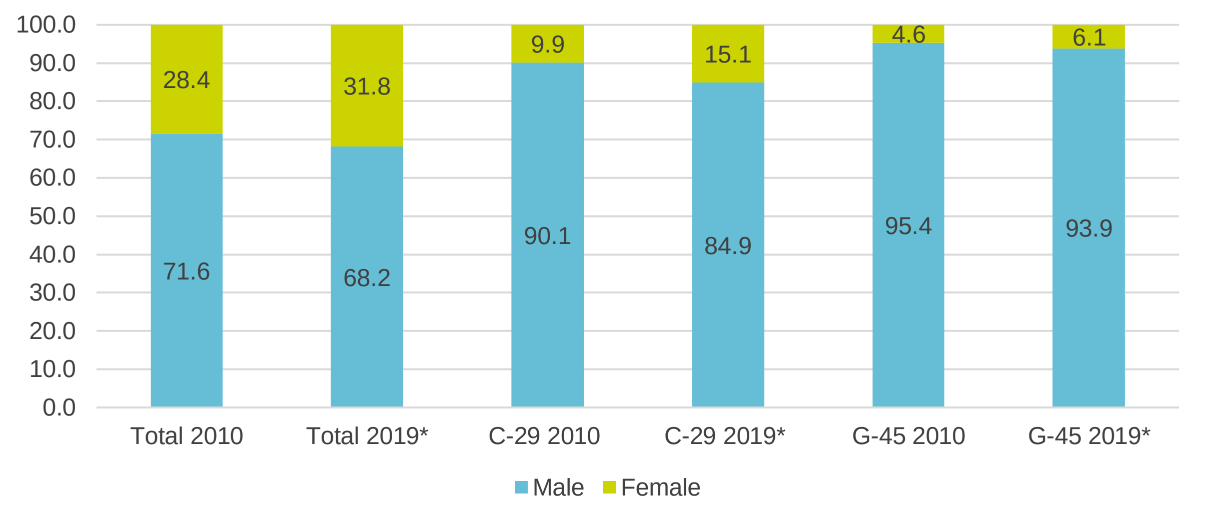


Note: (*) Since 2014 LFS has been implemented continuously in Turkey, but there was a series break in 2014. This led to the differentiation of the previous series of indicators and eliminated the data's comparability.
Source: Turkstat, calculation from LFS datasets.

In the context of Turkey, the data indicate that the manufacturing sub-sector is highly dependent on medium-level technical skills that are typically provided via technical/vocational education and training, usually at ISCED levels 3–4 (e.g. craft and related trade workers, and technicians). Nevertheless, a decline has been recorded in medium-skilled workers, from 44.5% in 2010 to 39.4% in 2019, with these gaps mostly filled by high-skilled workers (Figure 3.7). Conversely, the trading sub-sector is much less dependent upon medium-skilled workers as their share is even lower than in total employment, albeit with a small increase discernible (from 17.3% in 2010 to 21.2% in 2019). This is very untypical for the trading segment of the automotive sector. In the interviews, however, the representatives of the trading/services sub-sector gave a more optimistic overview regarding the educational attainment of their workers. According to the interviewees, most salespersons had either a university degree or a high school qualification, while the spare parts and repair services areas were perceived as including many more low-educated workers.

Another characteristic of the automotive sector is the male-dominated nature of the jobs. A significant gender gap in the overall workforce has already been highlighted in Section 3.2, but the automotive sector is an extreme case. Figure 3.8 shows that women constituted only 31.8% of total employment in 2019 (with a small increase since 2010). In the automotive sector, this figure drops to a mere 15.1% in the manufacturing segment and to only 6.1% on the trading side. Despite these low levels, the share of women working in the manufacturing segment has shown a rapid rise (52% more women have been employed since 2010), which is probably linked to the overall increase of highly educated workers in this segment. The respective share of women in the workforce in the EU (EU-28 average) in 2019 was 46.3% of total employment, 24.7% of automotive manufacturing workers, and 16.0% of those employed in the trading segment[20].

FIGURE 3.8 EMPLOYMENT BY GENDER: TOTAL, C-29 AND G-45, 2010 AND 2019 (%)

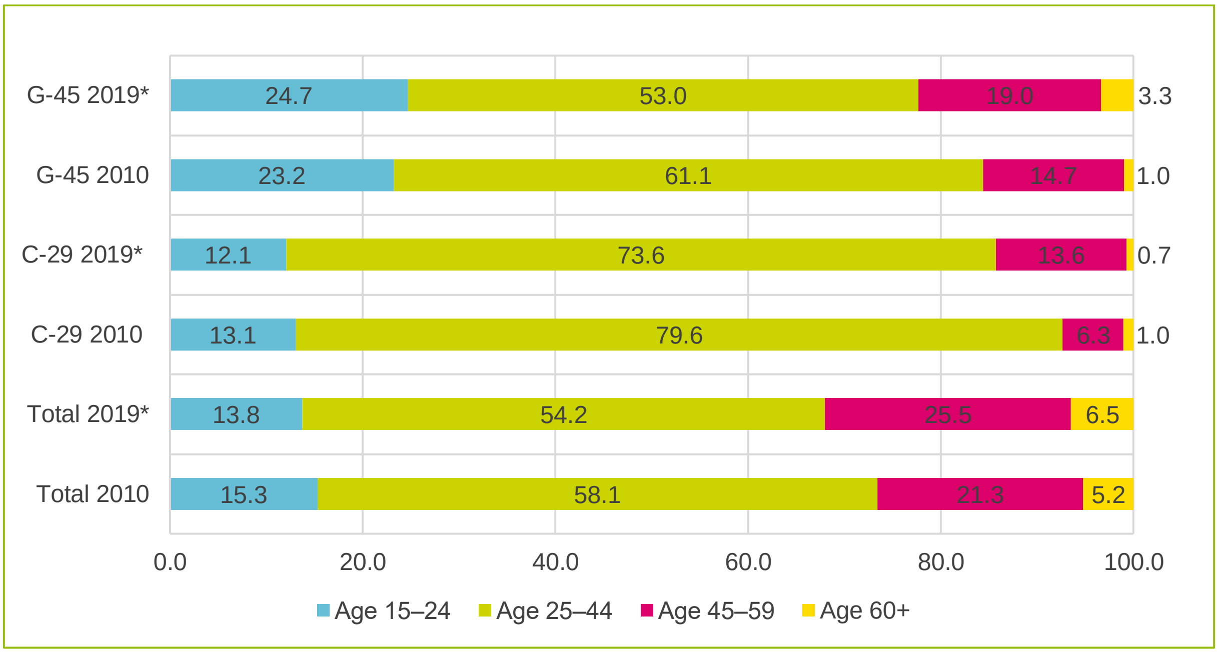


Note: (*) Since 2014 LFS has been implemented continuously in Turkey, but there was a series break in 2014. This led to the differentiation of the previous series of indicators and eliminated the data's comparability.
Source: Turkstat, calculation from LFS datasets.

Compared with the EU, the automotive workforce in Turkey is younger. Figure 3.9 shows the distribution of various age groups in the workforce within both total employment and the automotive sub-sectors. Interestingly, almost 25% of the workforce in the trading segment of the automotive industry was in the 15–24 age group in 2019, while 53% was aged 25–44 – albeit this figure has been decreasing slightly since 2010. In the manufacturing segment of the automotive sector, almost 74% of the workforce was in the 25–44 age group, followed by almost 15% in the 45–59 category. These numbers indicate a very young workforce in the Turkish automotive sector, even compared to the age groups in total employment. Overall, 85.7% of the workforce in the manufacturing segment of the automotive industry is below 44 years old, while the same group comprises 77.7% of employees in the trading segment, compared to 73.4% in total employment. Although a very slow and gradual increase in workers' age can be seen since 2010, these numbers are not comparable with Europe, where only around half of the automotive workforce is below the age of 44 (Eurostat).

[20] Eurostat Labour Force Survey [LFSA_EGAN22D].

FIGURE 3.9 EMPLOYMENT BY AGE GROUP: TOTAL, C-29 AND G-45, 2010 AND 2019 (%)



Note: (*) Since 2014 LFS has been implemented continuously in Turkey, but there was a series break in 2014. This led to the differentiation of the previous series of indicators and eliminated the data's comparability.
Source: Turkstat, calculation from LFS datasets.

3.5 Automation trends in the sector

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. However, automation has already started to influence the current and future demand for skills in the automotive sector, and this also applies in Turkey since automation and robotics are already routinely used in production processes. As seen previously in Figure 3.7, between 2010 and 2019 a slight trend towards a declining share of medium-skilled workers is visible at the expense of an increasing proportion of high-skilled workers in the manufacturing segment of the automotive industry. The decrease in medium-skilled workers in this sub-sector (from 44.5% in 2010 to 39.4% in 2019) might be partially explained by a hollowing-out phenomenon[21], with this group mostly being replaced by increasingly high-skilled workers (from 17.3% to 25.3%). According to a future of work study which surveyed Turkish senior executives and labour union representatives[22], two-thirds of respondents forecast a higher automation trend, which was expected to increase productivity growth and make the national economy more competitive.

Statistics from the International Federation of Robotics (2020) show that Turkey has become a promising emerging market for robot installations as it is an important production site for cars and commercial vehicles. The country's economy, particularly its automotive sector, is well integrated into

[21] Hollowing out phenomenon refers to labour market development where the share of high-skilled and low-skilled jobs increased, whereas those jobs that were in the middle have lost employment share over time. As a result, jobs have polarised and opportunities and earnings in the middle-level jobs have declined.

[22] 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 (2020).

European supply chains and thus affected by global robotics trends. Table 3.7 shows the stock of industrial robots in selected countries from 2014 to 2019[23]. Turkey occupies the 20th position in terms of industrial robots used, with over 15 000 in 2019. Its use of industrial robots increased by 19% between 2014 and 2019. The Turkish automotive sector (manufacturing segment) is the most important customer for industrial robots, with 42% of all robot installations in Turkey taking place in the automotive sector, followed by the metal industries (16%), plastics and chemical plants (11%), the electrical/electronic sector (4%), food/beverages (5%), and others (23%) (IFR, 2020). Thus, the use of industrial robots is spreading in the country, requiring adaptations in labour profiles and skill sets, with an increasing need for cognitive, digital and STEM skills.

TABLE 3.7 OPERATIONAL STOCK OF INDUSTRIAL ROBOTS AT YEAR-END IN TURKEY AND SELECTED COUNTRIES

Countries	2014	2015	2016	2017	2018	2019	2014–19
Germany (5th)	175 768	182 632	189 305	200 497	215 795	221 547	+5%
Czechia (16th)	9 543	11 238	13 049	15 429	17 603	19 391	+15%
Poland (18th)	6 401	8 136	9 693	11 360	13 632	15 769	+20%
Turkey (20th)	**6 286**	**7 940**	**9 756**	**11 599**	**13 498**	**15 022**	**+19%**
Slovakia (29th)	3 891	4 378	6 071	7 093	7 796	8 326	+16%
Russia (32nd)	2 694	3 032	3 366	4 028	4 994	6 185	+18%
Israel	938	1 080	1 278	1 533	1 770	1 979	+16%
Morocco	128	142	173	230	536	746	+42

Source: IFR (International Federation of Robotics), 2020.

One of the key elements in automation is the robot density in manufacturing – measured as the number of industrial robots per 10 000 employees. According to the International Federation of Robotics (2020), currently more than 2.7 million industrial robots are in use in the world, with 73% of them installed in five countries (China, Japan, US, Korea and Germany). The most widely used industrial robots by application are those for handling and welding, followed by assembling, cleanroom work, dispensing and processing. Thus the robot density in the manufacturing sector varies widely across countries, from 918 in Singapore and 346 in Germany to 169 in Slovakia, 147 in Czechia, 44 in Mexico, 49 in Israel and 29 in Turkey[24].

Controversial views exist about the impact of automation in medium-income countries. According to *The Economist* (2018), for example, middle-income countries will be widely affected by automation and find it hard to adapt without a strong education base (up to upper secondary level). For example, *The Economist* ranked Turkey in 15th place among 25 countries in its automation readiness index (*The Economist*, 2018). In the Turkish automotive sector in general, technological changes associated with Industry 4.0 and the like are seen to pose a threat to jobs in the middle of the occupational

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[23] According to the International Federation of Robotics (IFR), an industrial robot is defined as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications (IFR, 2020).

[24] Examples of robot density in the manufacturing sector are: Singapore (918), Korea (855), Japan (364), Germany (346), Sweden (277), Denmark (243), Hong Kong (242), US (228), Italy (212), the Netherlands (194), Spain (191), China (187), France (177), Slovakia (169), Czechia (147), the UK (89), Israel (49), Poland (46), Mexico (44), Turkey (29), Russia (6) (IFR, 2020).

hierarchy, which are common in the automotive sector. A study by Sumer (2018) suggests that the jobs most at risk in Turkey are, amongst others: clerical occupations, services and sales workers, plant and machine operators and assemblers, and even technicians and associate professionals. These are all jobs which are commonly found in the automotive sector. On the other hand, craft and related trades workers are seen as more secure.

Looking at the whole Turkish economy in general, the McKinsey study (2020) concluded that by 2030, with the impact of automation and digitalisation, 7.6 million jobs could be lost, and 8.9 million new posts 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 to take place, 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 joining the workforce will need to be equipped with the latest skills required in the job market (McKinsey, 2020).

The McKinsey study further reports that even though the automation potential for work activities is considerable, just 2% of all occupations in Turkey are completely automatable, while for 60% of jobs at least 30% of the activities involved could be automated – generally speaking, these jobs include elements of repetitive work. As noted by McKinsey, manufacturing (including automotive production) is the sector with the most automatable tasks: for 12% of assembly line workers and machine operators, 90% or more of their activities could be automated, while 20% of the working time of manufacturing workers and machine operators is spent performing actions with a 75% automation potential.

A recent survey of sector representatives by TISK (together with TAYSAD and OSD) points to a number of emerging skills needs in the automotive sector (TISK, 2020). 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 the country. Although OEMs are quickly catching up, small auto suppliers are experiencing some difficulties. The state has established a few model factories to serve the sector by offering 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; the internet of things; cloud computing; cyber security; horizontal/vertical software integration; sensors; image processing; additive manufacturing; augmented/virtual reality (AR/VR); and simulation (TISK, 2020). As a result, it is highly likely that the automotive sector will increasingly require personnel competent in the use of these technologies, with potential training needs at all skill levels.

Within this context, the automotive industry is setting an example of growth, not only by investing in manufacturing, but also by supporting the design and engineering aspects of the sector. As a result of this, R&D and design expenditures, as well as the industry’s infrastructure and workforce, are increasingly supported and promoted by the government through different funds, enabling automotive companies to develop cutting-edge technologies. TAYSAD, as one of the most important sector associations, represents 17% of all R&D and Design Centres in Turkey, with a total of 155 such facilities (TAYSAD, no date). All these centres have developed a number of nationally and internationally funded projects on themes linked to the automotive sector, offering crucial engineering and manufacturing expertise in various fields.

Compared to the manufacturing side, the trading arm of the automotive sector is lagging behind in following these developments. It is obvious that the Covid-19 pandemic has turned face-to-face sales into online sales; however, companies' preparations for digital sales and services are proceeding slowly, especially in small companies. Nonetheless, Covid-19 has accelerated awareness of digitalisation and future trends, which has forced the sub-sector to quicken its pace. The sector association OYDER provides support and training for its members, recently focused on digitalisation and online sales, and it has also published reports on the topic – the latest being 'The future of automotive dealers in Turkey' (OYDER, 2015).

3.6 Conclusion

The automotive sector has been, and continues to be, an important part of the Turkish economy. Among the two sub-sectors of the automotive industry, the manufacturing side (C-29) is certainly highly developed and follows future trends closely. This is also facilitated by the Turkish vehicle manufacturers being integrated into global value chains, and especially by their connections to the European value centre. As a result, this industry represents an important source of output and export growth and is a key provider of relatively high- and medium-skilled employment (notably skilled manual work in production centres). The trading segment of the automotive sector lags further behind in capitalising on these developments, and its current workforce is largely low- and medium-skilled, and employed on less good terms.

Compared with countries that have substantial automotive sectors – such as Germany and Slovakia – Turkey has fewer medium-skilled technicians at ISCED levels 3–4 (the levels often associated with craft and related trades jobs). At the same time, there is a big difference in workforce education levels between two sub-segments of the automotive industry; for example, the manufacturing segment employs workers with much higher skill levels, while the trading arm is staffed to a large extent by workers with low education attainment (less than upper secondary education), which makes adaptation and further learning more difficult. Both sub-sectors are heavily male-dominated, with women making up only around 10% of workers in the whole automotive sector. The sector is also dominated by young people, with more than three-quarters of workers aged between 15 and 44.

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. 'Grey-collar' refers to employees who are not classified as either white or blue collar, and who work in occupations that incorporate some of the elements of both blue- and white-collar jobs, while generally falling between the two categories in terms of income-earning capability[25]. One would typically expect people in these roles to be qualified or skilled to a level equivalent to at least ISCED 3 or 4, or even ISCED 5A. But, as indicated above, compared with other countries in Europe with a large automotive sector, relatively few people are educated to this level of technical ability in Turkey. This potentially poses a challenge to the VET system – how can it increase the percentage of the workforce skilled and qualified to this level?

[25] For the information of general readers, grey-collar workers often have licences, associate degrees or diplomas from a trade or technical school in a particular field. Unlike blue-collar workers who can often be trained on the job within several weeks, grey-collar workers already have a specific skill set and require more specialised knowledge than their blue-collar counterparts. Examples include flight attendants, paralegals, technicians, firefighters, police officers, emergency medical service personnel, chefs, childcare workers and non-physician healthcare workers.

3.7 Main findings

- Overall, 812 000 people were employed in the sector in 2019, accounting for around 2.9% of the total employment in Turkey. Out of this number, 33.6% work in the manufacturing segment (273 000), and the rest in the trading division (539 000). The worker profiles of the two sub-segments are quite different and are analysed separately.
- The manufacturing part of the automotive industry is an important source of relatively high- and medium-skilled employment. The evidence shows that much of the employment in the sector is concentrated in craft and related trades occupations (essentially skilled manual work), which comprise a number of activities with a high potential for automation. As a result, these workers will see their jobs and tasks reshaped and will need to improve their skills or be reskilled in order to remain competitive in the labour market.
- The trading branch of the automotive sector is trailing behind the manufacturing side, with the current workforce occupying largely low- and medium-skilled jobs that enjoy fewer benefits. The majority of workers have a low level of educational attainment (less than eight years of schooling), which may be a disadvantage in terms of having core functional skills, taking up new learning opportunities and improving their soft skills. This could run the risk of creating a bottleneck in the sector.
- Other countries with substantial automotive sectors have education systems which produce many more of the people qualified at the medium technical level required to fill these types of jobs, and the share of low-educated candidates is very low compared to that of Turkey. In the medium term, this difference could lead to a greater innovation capacity in those countries in terms of production processes and higher productivity in their business structures.
- Technological change may transform the demand for skills – shifting from blue- to grey-collar jobs in Turkey – as has happened in other countries. These latter jobs tend to be those 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. The VET and university systems in Turkey may need to rethink their strategies in the future to accommodate such grey-collar jobs.

4. KEY DRIVERS OF CHANGE IN THE SECTOR

KEY ISSUES

- 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 outlined the broad contours of skills demand in the automotive sector. In moving towards a more detailed analysis of skill needs (i.e. what are the actual skills people deploy in their jobs and how are they likely to change?) it becomes necessary to understand the factors driving innovation in the sector and the technologies associated with these developments. The future of the automotive industry is not just about technological change, it is also vital to consider a variety of non-technological factors which will shape the future of the industry. In the sections below, consideration is given to the range of technological and non-technological factors driving change in the automotive sector in Turkey.

4.1 Identifying drivers of demand

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

Figure 4.1 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, a focus on reducing emissions could turn to a consideration of electric vehicles, which then leads to new design solutions, vehicle optimisation and programmes for simulation (yellow, light blue and green clusters respectively). Examining all the clusters provides the basis for identifying potential candidates for drivers of change.

A driver of change is considered to be a factor that strongly influences the evolution of future scenarios (for a literature review of sectorial drivers, see Stolfa et al., 2019). By combining the clustering with an analysis of change over time (i.e. the number of scientific papers published each year), it is possible to identify where phenomena are increasing (see Figure 4.2 for example).

FIGURE 4.1 NETWORK DIAGRAM OF KEYWORDS RELATED TO THE AUTOMOTIVE SECTOR IN TURKEY FROM THE ANALYSIS OF SCIENTIFIC PAPERS

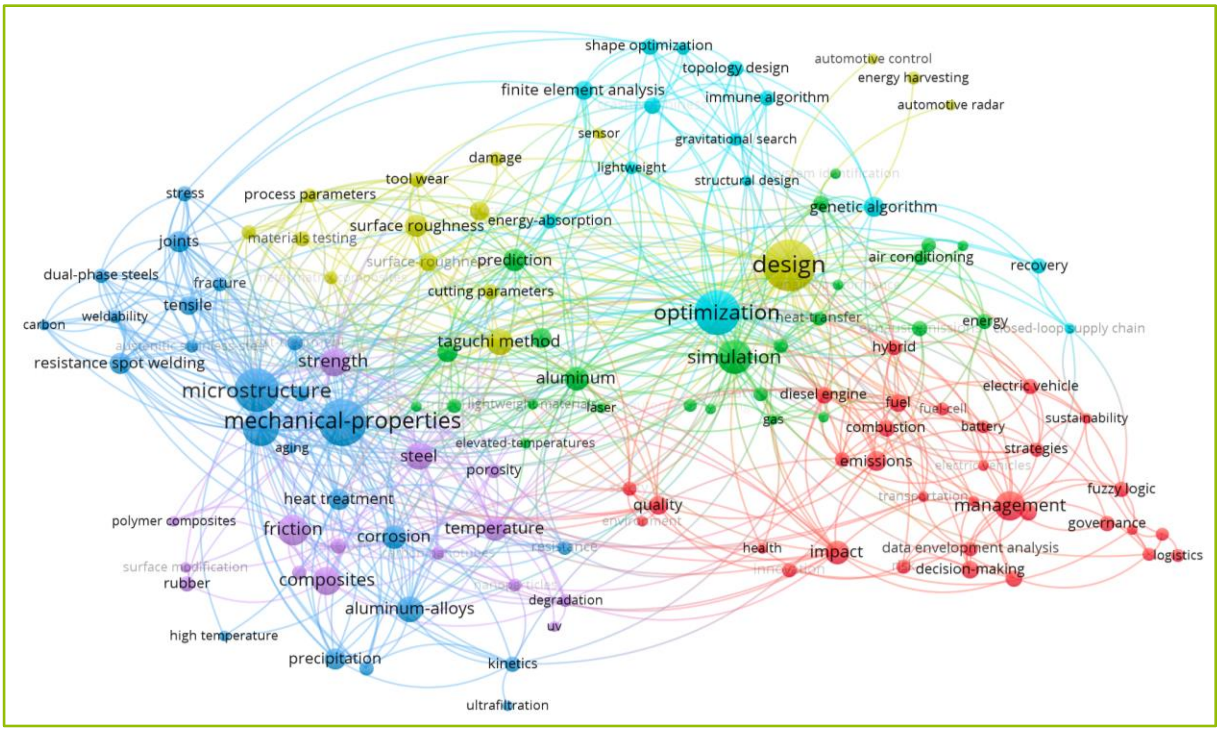
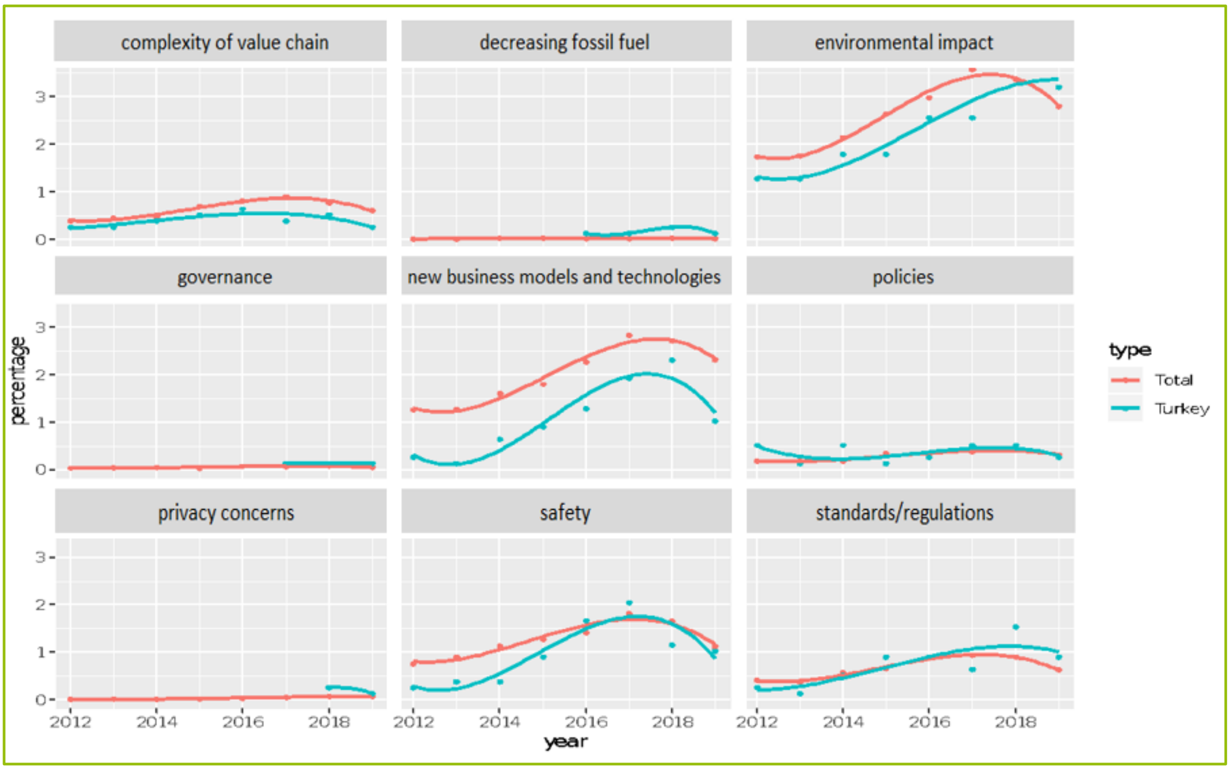


FIGURE 4.2 DISTRIBUTION OVER THE YEARS OF KEY CONCEPTS IDENTIFIED IN THE ANALYSIS OF SCIENTIFIC PAPERS ON THE AUTOMOTIVE SECTOR



From the text mining described above, besides technological drivers, a series of non-technological dynamics of change were also identified – listed below. Each of these is capable of introducing a number of innovations to the automotive industry, which, in turn, may prompt a demand for new skills, affecting companies' recruitment practices and, in some cases, creating new sector profiles.

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: 'an increase in customers' expectations and the customisation of products' and 'economic and political instability'. Moreover, the cluster of 'design' has been better contextualised in terms of the strategy evident in Turkish companies to upsell along the value chain. In this regard we can see 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 now encompass the product design process entirely within their organisation, with businesses generally evolving from a mere supplier role to that of a co-designer or in some cases a designer, producing original innovative products. This change is leading to a dramatic upgrading of their position in the automotive value chain. For some companies, this evolutionary process is not a strategy for the future but has already happened, while for others it is still underway.

In the following sub-sections all the principal drivers of change are described, while in the next paragraph those of a technological nature 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. Research into new materials, often in relation to electric mobility (e.g. lightweight components, new batteries, etc.), also has an important impact, both on its own account and because of the need for new tools and machines to accommodate 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 the interviews confirmed, has received a boost in recent years), down to software to manage the supply chain (e.g. ERP software), are radically changing internal processes and organisation (Bertoncel et al., 2018). Clearly, digitalisation and smart factory systems translate into new skill requirements and, potentially, the emergence of new job profiles (Jerman et al., 2020), 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 have been introduced to minimise human error and thus reduce road fatalities (cf. the driver's '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 are not able to innovate and adapt will be cut off from global value chains and are unlikely to 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 technological innovations (Rachinger et al., 2019). For example, online trading will reshape the distribution chain, 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 a general worldwide trend in mobility behaviour, moving towards renting or sharing cars instead of owning them, manufacturers will have to find new ways of creating value, for example through offering more services, and particularly so once self-driving cars are reliable enough for everyone to have access to vehicle fleets at all times. The availability of 3D printing techniques for rapid manufacturing also plays a relevant role, leading to a reduction in the production costs for certain parts and enabling prototypes to be moved easily 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 the automotive sector, both in the EU and Turkey (European Commission, 2017; Taymaz and Yilmaz, 2008). Participation in GVCs is one of the key drivers of successful productivity diffusion in a globalised world (World Bank, 2019b), and, indeed, 72% of Turkish automotive production is destined for export, often to feed the supply chain of international OEMs. The benefits are not only economic, but related, for example, to positive technological spillovers into other sectors and the acquisition of important know-how and best practice examples. Yet, deepening integration into GVCs exposes countries to a greater number of shocks, although 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' (Ziemann and Guérard, 2016, p. 3). 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 making original parts with greater added value, deepening their GVC integration and moving towards its higher end. National global players, such as TOGG for example, are also starting to appear. A competitive advantage that Turkey has with respect to GVCs is its geographical proximity to Europe, a factor that may become even more important because of changing trends in international trade, leading to the country offering a replacement for products from the Far East, while the Covid-19 pandemic is going to accelerate this trend.

The complexity of the value chain and the increased relevance of logistics

Logistics is a central component of the whole value chain of the automotive sector. This prominence is surely driven by globalisation but also by the changing attitudes of customers who increasingly demand a greater variety of products. Due to the sheer scale of the movement of goods that this implies, the logistical chain is also clearly related to the issue of environmental impact. The complexity of products, in terms of the number of sub-assemblies, and the high requirements in quality standards lead companies to coordinate their actions more efficiently in order to supply carmakers with the necessary parts and components. Moreover, most of the problems 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. the aftermarket or OEMs), it is expected that online trading will reshape the chain of distribution, and the number of actors along the chain will be reduced.

International competition

Strong international competition, for example from BRICS (Brazil, Russia, India, China and South Africa) countries, is another very important driver, particularly also in light of the low profit margins of the sector (4% in the best cases) that guide many strategic choices (European Commission, 2017; ErnstYoung Turkey, 2016). The pressure on suppliers to obtain lower prices is continuous. This leads to adopting new production processes and techniques to optimise 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 entered the market with electric vehicles or autonomous driving car solutions. Since even the key players will change, the ability to adapt is critical for survival.

Increasing customers' expectations and the customisation of products

As both the desk research and the interviews pointed out, the changing attitude of the customers is a critical factor in this sector. Consumers' expectations are much higher than before and highly diverse, so companies must work on the differentiation of products and customer satisfaction now more than ever. The costs and quality of products also need to keep pace with customers' demands. This contributes to increasing the level of competitiveness within the sector, but also to creating the opportunity for companies to review and improve processes by introducing innovative solutions. Indeed, digitalisation is a necessary solution to manage customisation, 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 (Bounya, 2018). Humphrey and Schmitz (2001) 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, a commitment to careful governance is critical for success in the market. For example, in Turkey, various companies have been encouraged to join forces to share the high costs of digitalisation or automation.
- Design. In the past, the Turkish car industry merely assembled cars or produced components at the request of international OEMs. However, over the years, Turkish companies have successfully managed to upgrade their functionality, and have started to produce new, higher-value, proprietary car components which are now exported all over the world. Many of the interviewed companies stressed how their ability to design new products (from innovative components for electric cars to sensors embedded in plastic parts) has constituted a major factor in their success and given them a decisive advantage over competitors focused only on reducing prices. This factor in turn has major implications in terms of the 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, as the market does not accept delays and issues of low quality. Improvements need to be made to the production lines themselves, by means of, for example, visual control by cameras, artificial intelligence for item control, and optical scanners for taking measurements. In turn this will affect the skills of the employees, not just the blue-collar workers but the engineers and white-collar staff as well.

Economic and political (in)stability

Over the last 30 years, Turkey has experienced recurrent periods of instability – erratic economic growth coupled with high inflation and a volatile currency (Rawdanowicz, 2010; BSIC, 2013, Noble, 2018). This has had various types of hampering impact on the sector: the possible withdrawal of foreign investments (which have to be replaced by national funding); the fluctuation of market prices and conditions, especially affecting the domestic market; the existence of trade barriers such as import/export taxes; and the higher costs of international loans for sector investments due to changing political conditions.

Public policies and incentives

As in many other countries (Federal Chamber of Automotive Industries, no date), the development of the car industry in Turkey has always been related to the government's policy decisions regarding infrastructure, urban development, and so on, while the fostering of a healthy national automotive sector requires national strategies at both the macroeconomic and microeconomic levels for promoting the development of production and sales. A recent example is the government's effort to support local brands in producing electric vehicles 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 (TÜBİTAK) has launched the Support Programme for Research, Technological Development and Innovation Projects in Priority Areas (TÜBİTAK-1003), with the automotive sector as a main target. Incentives and tax policies are also relevant; in Turkey the purchase of new cars is heavily taxed, which leads 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 have affected the car industry. The adoption of technologies is not only made possible by recent advances in software, hardware and communication systems, but is often prompted by the introduction of various applications and regulations, in particular those concerned with environmental standards (see Napolitano et al., 2019; Maes et al., 2019; Kurien et al., 2019).

Safety requirements

The automotive industry has always been highly focused on safety issues, from braking systems to the protection of passengers (Yunhan et al., 2017). There is currently a renewed emphasis on this aspect in relation to autonomous cars; alongside the obvious avoidance of crashes, there is also a need to overcome customers' concerns about the reliability of the technology (Peng et al., 2019). Indeed, due to high-profile crashes involving autonomous test vehicles in the US, nearly three in four Americans (71%) are afraid of fully self-driving cars (Mohn, 2019). As a result, companies in the automotive industry are working to ensure these cars' safety, for instance by developing specific platforms which mitigate the threats of the untrusted code used to drive the cars, or by implementing new collision-avoidance systems.

Environmental impact and a greener economy

The automotive industry and its products have a significant impact on the environment. Both 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 effects of car pollution (see Vaz et al., 2017). The rise of hybrid/electric cars is clearly prompted by the need to reduce CO_2 and other emissions (Mahroogi and Narayan, 2019), but the entire industry is called on to embrace more sustainable production (Mock, 2016). 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. A related aspect is the importance of the energy transition process in Turkey, also linked to the green aspects of the automotive sector thanks to a more efficient use of energy. Moreover, compliance with environmental regulations will also benefit the sector competitively. Due to the special trade relations between Turkey and the EU member states as a result of the Customs Union, since 1996 the country's automotive sector has been a winner in terms of custom-tax-free exports. As Turkey's involvement in European global value chains increases, the green transformation of Turkey will be increasingly important for the sector.

Privacy concerns

In the era of intelligent transportation systems (ITS), vehicle-to-infrastructure (V2I) communication, and data sent to roadside units, the leaking of sensitive information from vehicles that may seriously violate privacy requirements, such as driving patterns and history (see Lu et al., 2019, Zeadally et al., 2020), is becoming a relevant issue for consumers. In this regard, various companies are developing systems for managing privacy concerns.

Decreasing fossil fuels

The growth of interest in various alternative technologies such as hybrid or electric vehicles is also a result of recurrent crises in the oil market and the decreasing stocks of fossil fuels (see Stanford, 2017; European Commission, 2017). It is believed that peak oil production has already been reached and we have now entered a phase of decline as fossil fuel reserves become harder to locate.

Preliminary findings about the impact of Covid-19

The big data analysis was conducted before Covid-19 reached Turkey and therefore cannot shed light on its consequences. However, preliminary studies on the sector at the global level indicate that Covid-19 also poses a threat to the automotive sector. To date, global forecasts indicate a 20% fall in sales to a level last seen during the 2008 financial crisis (*The Economist*, 2020), although the situation remains highly uncertain. According to a national newspaper (*Hürriyet Daily News*, 2020), Covid-19 could result in a USD 5 billion loss for the sector in Turkey, but some of this loss could be offset by increased demand for parts from Europe given the difficulties in sourcing parts from its main supplier – China.

The car industry shows both a high sectoral risk for negative economic effects (mostly due to plants being forced to close as non-essential businesses) and a high risk of employment vulnerability (since many of the tasks linked to the production of vehicles are not suitable for teleworking) (Demir Şeker et al., 2020). During the interviews for this study, representatives from the Turkish companies provided information on various problems they had experienced in the short term because of the pandemic, including:

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

However, as a result of government support provided during the lockdown period, employment has been preserved in the sector, and many of the interviewees expected the situation to return to normality relatively soon (although some companies expressed concerns that the crisis would continue and incentives from the government would decline).

In the opinion of some interviewees, there is a chance that the current crisis could even lead to increased opportunities for the sector in the long term. First, although customers may be reluctant to spend money on new cars, they may also be unwilling to use public transport because of infection risks, causing a turning back to private cars; thus, the overall balance could even be positive. Moreover, customers will always need spare parts for the existing vehicles (the aftermarket).

Second, and more importantly, to overcome consumer reluctance about making purchases that involve a high level of commitment, new business models, such as rentals and leasing, will further emerge and develop, creating new opportunities (Dertouzos et al., 2020). In the same way, an increase of demand is expected due to the responses of the automotive industry to new challenges and the rise of new actors (such as TOGG in Turkey).

Third, Covid-19 highlighted the fragility of over-stretched and insufficiently diversified supply chains and will lead to a return to more localised production, or at least to greater emphasis on geographical proximity in supply and demand chains, with consequences for both local investments and global trade. Local-to-local supply chains will provide more flexibility, and eliminating the incremental costs of redundant sourcing will outweigh the hazards of sole sourcing. In fact, investments in the Far East, increasingly seen as less competitive, especially by foreign investors, were already falling, and the pandemic has only exacerbated this situation. This has created an opportunity for Turkey, because of its competence in automotive manufacturing and its close proximity to the major European global value chain and consumer market (which is already one of the main competitive advantages of Turkish manufacturing).

Finally, the crisis could boost technical innovation. Companies will be prompted to adopt digital and analytical tools as they recognise the real value of predictive monitoring and supply/demand matching. Moreover, while before Covid-19, the implementation of automation was slow because of long return-on-investment times and low wages, now investing in robots will be more attractive as a means of counteracting the negative effects of future pandemics. However, the rate at which the adoption of new production technologies will occur is difficult to foresee. At the moment, there is little real evidence of this happening, apart from the introduction of smart working systems. Some companies are more ready than others and will seize the opportunities offered, while others lag behind. The Covid-19 crisis may also delay investment decisions for many companies, which will slow the pace of change.

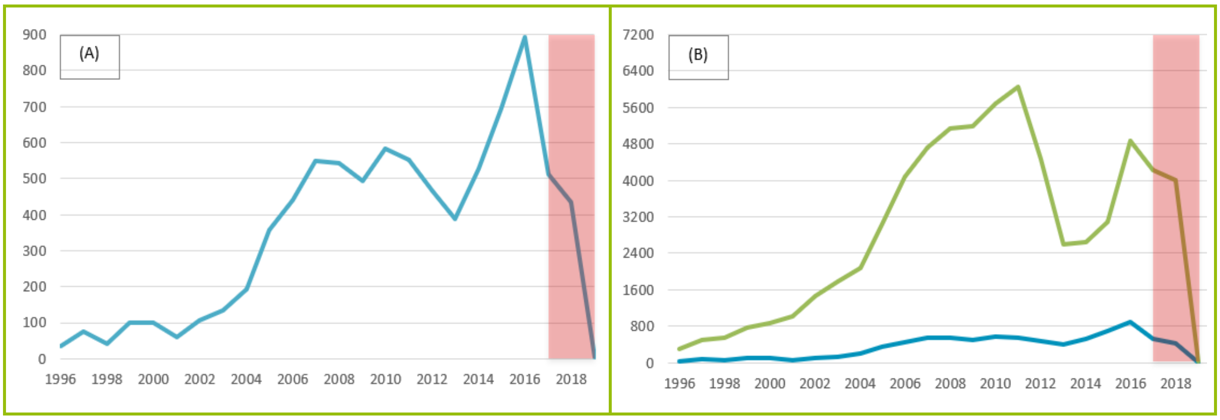
4.2 The role of innovation

The discussion below deals with technology as a driver of change. It is important to note that the focus is not on technology *per se* but on its potential to influence, through its adoption, the demand for employment and skills. From a methodological point of view, the functional use of technology is emphasised rather than 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, this 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 regarding the actual impact of technology use in companies. By looking at the functional use of a particular technology – i.e. the actual problem it solves or the beneficial practices it enables – it is possible to study its tangible impact in the real world. Moreover, even if a specific technology is not eventually adopted, if the need expressed by its deployment is real, another substitute technology will emerge in the long term. In this sense, the functional approach allows for an understanding of the obsolescence and/or resilience of certain jobs or occupations and enables those involved to forecast, or even design, 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 its citizens' aptitude for invention, as measured 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 picture of innovation in the country. Figure 4.3A shows the patents filed from 1996 to 2018 in the automotive sector in Turkey, while Figure 4.3B compares these numbers with the total number of filed patents in the country. Figure 4.4 compares the number of automotive patents filed in Turkey (Figure 4.4B) with the total number of patents worldwide (Figure 4.4A) related to the automotive sector, expressed as a percentage.

FIGURE 4.3A TURKISH AUTOMOTIVE PATENTS, 1996–2018; 4.3B COMPARISON WITH THE TOTAL NUMBER OF TURKISH PATENTS



Note: A red screen covers the last year and a half of each graph, since the number of filed patents here cannot be considered final, due to the 18 months of secrecy that is imposed 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 (see also Figures 4.4A and 4.4B).

As can be seen from Figure 4.3B, except for the period 2011–13, overall innovation has been growing in the country. Patent filing specifically related to the automotive industry has increased in the last 15 years, reaching nearly 2 000 patents in the last three years and representing nearly 15% of all Turkey's patent filings. As revealed by the desk research, the recent positive trend is also the result of a supporting action from the government, which financed research (e.g. through TÜBİTAK), but also incentivised the filing of new patents and enforced their protection. The fall in numbers around 2013 is likely related to the consequences of a period of economic instability. If that assumption is correct, the fact that the rate of innovation is so dependent on the country's overall economic development is an indication that R&D capabilities in the country are still fragile and not self-sustaining.

FIGURE 4.4A WORLDWIDE AUTOMOTIVE FILED PATENTS; 4.4B TURKEY'S AUTOMOTIVE PATENTS (EXPRESSED AS A % OF THE TOTAL NUMBER OF AUTOMOTIVE PATENTS WORLDWIDE)

Turkey's automotive industry is also gaining an increasing relevance worldwide, from both an economic and a patent-filing point of view. Even though the number of Turkey's automotive patents represents a small percentage of the total filed 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 demonstrating that Turkey has been contributing more and more to innovations in the worldwide automotive industry (Figure 4.4B). This trend confirms the fact that Turkish companies are moving towards 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 taking place in the sub-sectors listed in Table 4.1, where it is reasonable to expect a change in the demand for both new jobs and skills in the near future. The list is ranked according to the intensity of the innovative activity, in descending order.

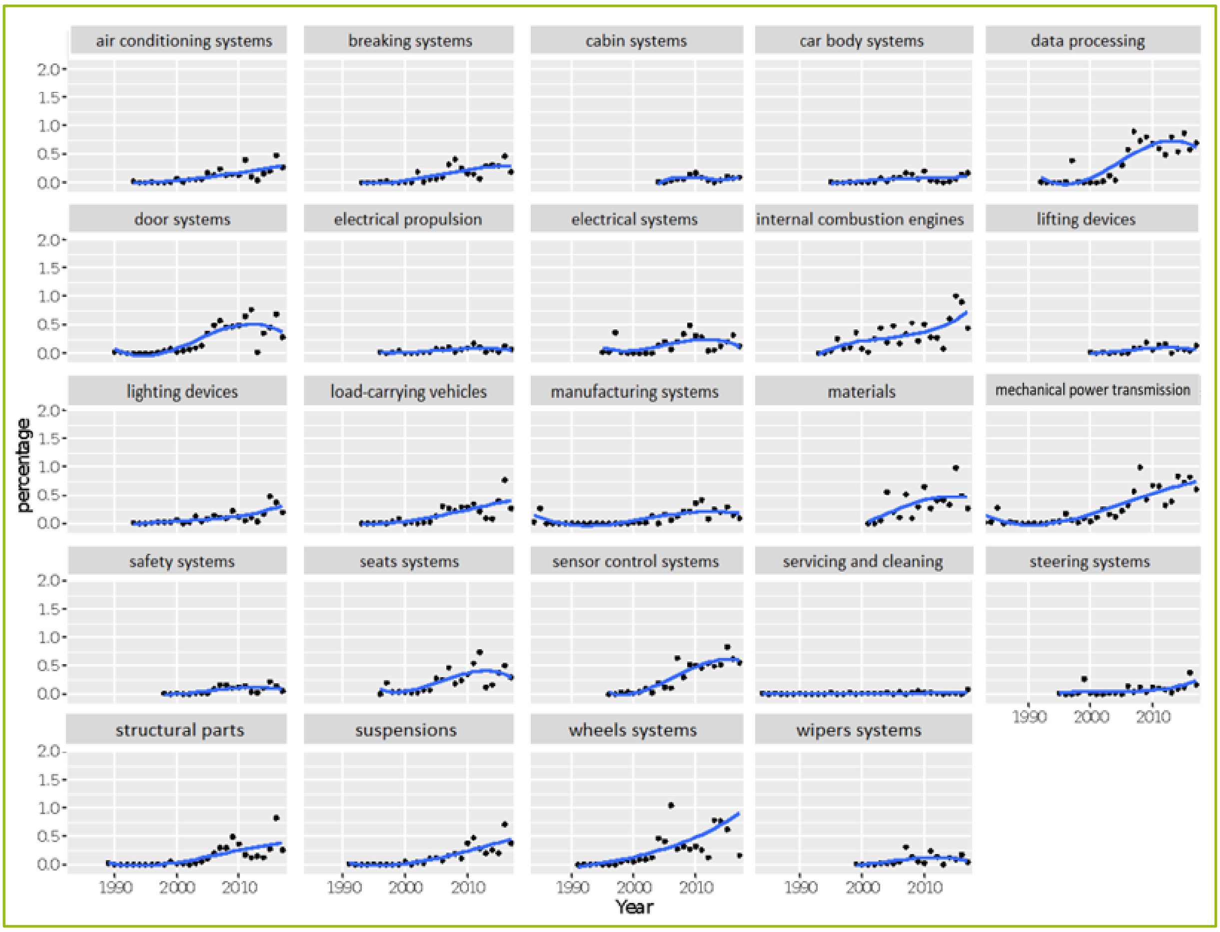
Out of all the 24 patent families listed in Table 4.1, the first half represents 80% of the total number of Turkey's filed patents in the sector. Clusters are consistent with the analysis of the drivers of change in Section 4.1, as well as with the idea of the functional use of technology. For example, the cluster regarding 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 for developing smarter products; and it shows the importance of privacy concerns related to new models of cars.

TABLE 4.1 FAMILIES (CLUSTERS) OF TURKISH AUTOMOTIVE PATENTS (RANKED FROM THE HIGHEST TO THE 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-carrying vehicles
309	Structural parts
300	Suspension systems
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 and cleaning

Representing the number of filed patents over the years, it is also possible to create temporal trends for each cluster, as shown in Figure 4.5. Compared with Table 4.1, 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 4.5 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 4.5 TRENDS FOR SPECIFIC TECHNOLOGIES



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 (note that the same technology can actually appear in several clusters, which will increase its significance):

- vision systems (cameras, software for image analysis);
- user interfaces, displays;
- computer data processing;
- memory units;
- electronic circuitry;
- servomotors;
- radio-frequency identification technology (RFID), wireless communication, etc.;
- various types of sensors (position sensors, textile touch pad sensors, speed sensors, fibre optic sensors, acoustic detectors, inductive sensors, etc.);
- control systems and circuits;
- elastomeric mixes for tyres;
- 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 systems);
- fuel cells and fuel cartridges;
- energy storage mechanisms, batteries, battery chargers;
- pneumatic and mechanic brakes;
- brake controls;
- lighting systems, LEDs (light-emitting diodes), LED chips;
- legged robots;
- robotic arms;
- compliant mechanisms;
- pumpless balancing systems and hydraulic systems.

Among the group of new technologies (at least new to 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; and computer processing systems. A second group, namely all types of sensors and 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 being in a 'smart car'. A third group of new materials, such as resins and composites, and in particular lightweight materials, is linked to reducing fuel consumption and thus environmental impact.

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

The interest in greener propulsion systems has led to 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 and compliant mechanisms, but also mechanical devices such as pumpless balancing or hydraulic systems. Quite a few technologies, in particular control systems, electronic circuitry, memory units, processing units, radio-frequency identification, user interfaces, data networks, sensors and all mechanical, electrical and hydraulic technologies, are not just growing quickly but appear to be growing transversally – i.e. they are found in multiple applications.

Figure 4.5 shows the temporal trends for the inventive activity of each specific technology. Assuming that increasing effort in R&D is a sign of interest by companies and that researched technologies will be implemented relatively soon, the plots may provide an estimate about the likelihood of that technology being adopted in the near future. Plots showing a very steep increase or numerically consistent activity (e.g. data processing in Figure 4.5) indicate shorter terms than others.

However, it is difficult to extrapolate any meaningful general predictions from this. Different technologies have different diffusion times, which is related to the specific characteristics of the sector in the country. Moreover, the actual adoption rate of a technology in production is different from that in R&D departments, and is affected by many non-technological factors, mainly of an economical and managerial nature. Thus, it is rather difficult to use the data to determine a clear time frame for the adoption of technological changes. One possible general consideration is that the automotive sector has a global dimension and is subject to highly competitive pressures, meaning that Turkish companies may be forced to adopt a set of technologies rather quickly.

Transversal technologies

Interesting considerations can be derived from an understanding of which technology or concept is found in multiple clusters. The main idea behind this further analysis is that technologies and topics that have transversal applications have an added value compared to those which are unique to one cluster only. Requests for job profiles with specific skills increase in importance if technologies are found and applied in more than one cluster. Specifically, if one technology is found in various application fields, its importance is greater since same or similar job profiles will be requested in more than one field. Concerning the Turkish automotive sector, among those clusters that have a higher number of patents, it is possible to find common technologies.

- Control units, control circuits and control systems recur in five of the 24 clusters listed in Table 4.1.
- Electronic circuitry, memory units, processing units, radio-frequency identification, user interfaces, data networks, recur in the two main clusters: data processing and sensors.
- Sensors themselves also appear as technology in various other clusters (position sensors, textile touch pad sensors, speed sensors, fibre optic sensors).
- All mechanical, electrical and hydraulic technologies (gears, connectors, compressed air, injection systems, electric motors and wirings, etc.) are present across various clusters.

The ways in which the above determines the skills needs of the sector in Turkey are considered in the next section.

Potentially disruptive technologies

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

- Artificial intelligence (AI). 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. Strong international competition leads to continuous optimisation research to reduce costs and save time in the production processes, while at the same time increasing productivity and quality. New paradigms of production such as lean management or so-called

'smart factory' production are being adopted. Specific technologies that are currently being implemented by most companies include:

- Robots and automation. Although it requires initial investment, 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 enables a full digitalisation of processes that can then be managed with software to ensure 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 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, additive manufacturing 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 high levels of customisation, companies' business will be affected by the introduction of 'smarter' products. In the future, components will be more integrated, sharing data among themselves. Increasing numbers of customers are asking for products that have data-gathering capabilities, meaning that components need to be digitalised and sensors integrated.
- New materials. Since the competition for lower prices and higher performance is continuous, for those companies which deal with component production the research into new materials is constant, from composites to the 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 each 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 vehicle market and many companies are working on the development of specific components related to the production of electric cars, for example: new types of lithium batteries; carriers that allow batteries to be isolated from water, heat and vibrations; new types of powertrains; fuel cells that can replace batteries; a range of lightweight components; and so on.
- Self-driving cars or rather aid-assisted driving cars. Many OEMs believe that self-driving cars will allow them to adapt their commercial offer to customers' needs. Apart from private mobility, another very relevant business is that of logistics (trucks) and intralogistics vehicles moving inside factories or between different buildings.
- Augmented reality/virtual reality (AR/VR). Virtualisation is an important technology for the sector, allowing people located in different sites to work together, and 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 as a response to the growing need for Turkish companies to research and develop original and innovative solutions in order to gain a competitive advantage and move towards the high end of the value chain.

4.4 Main findings

- Many factors are influencing the evolution of the sector, from changing customer expectations and habits to a greater integration into global value chains. The complexity of the scenario also calls for long-term strategies 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 included above) show a positive trend of adoption, with possible implications for related job profiles and skills.
- According to the interviewees, certain technologies, from AI to electric and autonomous cars, have the potential to completely disrupt and reshape the sector's production and business models.
- New technologies and actors coming from other sectors (such as Google or Apple) are already redefining the traditional market by introducing new vehicle models. The ability of companies to quickly adapt their business models and strategies is critical for survival.
- Transversal or cross-sectoral technologies (i.e. those required by various sectors or sub-sectors) are becoming increasingly apparent in the sector. The fact that many technologies are interrelated indicates the need for skills covering various technologies.
- The ways in which new technologies are introduced and the extent to which they sit side-by-side with older technologies potentially create a complex set of skill demands.
- The growing trend for innovation, the high volumes of products exported and the international value chain that links Turkey to other global players all have the potential to create new jobs in the sector.

5. CHANGING JOBS AND SKILLS DEMANDS EXPERIENCED BY THE SECTOR

KEY ISSUES

- Analysis of the main occupational profiles used in the sector and the evolution of the skill content of certain occupations as a result of the changes occurring in the industry
- Examination of the new tasks and functions which have emerged in the jobs and/or occupations in this sector, as well as a review of the old ones that have disappeared (or are likely to disappear)
- Assessing the impact of the drivers of change on labour and skills demands and 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 innovations, this chapter focuses on the implications of these changes. Based on the results of the data mining and the company interviews, two groups of occupations emerged as likely to be increasingly sought after in relation to such technological advances (see Section 5.1): (i) technical professional and associate professional occupations (high-skilled workers); and (ii) trades workers and machine operators (medium- and low-skilled workers).

Section 5.2 discusses the new skills needs that are emerging for existing jobs and newly evolving jobs or occupations. Attention is also given to jobs or occupations which may become obsolete. Finally, 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 as a result of the types of technological change described in the previous chapter.

5.1 Technology-related occupations

Identifying emerging jobs and skill needs

Technology-related occupations are staffed by those who are competent to manage and use a given technology. The key assumption is that a growing interest in a certain technology (as shown by patents filed and/or debates in scientific papers) is associated with a growing need for the skills associated with the use of that technology. The scale of skills 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 structures.

There are various possible ways to link the information on technologies derived from text mining to possible future skills needs; the following procedure was followed in this study. The list of relevant technologies extracted from the literature (see Section 4.3 above) was compared the occupations listed by the European classification system ESCO, using semantic matching algorithms (i.e. algorithms able to find semantic connections between different concepts based on a number of factors including contextual information). Each occupation in the ESCO database includes a description of the role plus a list of the competences, skills and knowledge considered relevant (either essential or optional) for its successful performance. The semantic algorithm looked for matches for each technology with all the concepts associated with an occupation. When a match was found, the occupation was considered associated with the technology. The entire procedure was automated by using ESCO's Application Programming Interface (API), which allows occupational data to be downloaded. Table 5.1 provides a few examples of the matching process.

TABLE 5.1 EXAMPLES OF THE MATCHING PROCESS FROM PATENT TOPICS TO ESCO'S SKILLS AND OCCUPATIONS

Topic from patents	Matched ESCO skill	Related ESCO occupation
User interface	Design user interface	ICT system developer
		Embedded systems software developer
		Electrical engineer
Pneumatics	Pneumatics	Fluid power engineer
		Forge equipment technician
Engines	Engine components	Rotating equipment mechanic
		Mechanical engineer
Sensors	Sensors	Electronics production supervisor
		Microsystem engineer
		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. Specifically, this can be achieved by using the list of skills, tools and technologies that 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 the 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). Note that the list does not imply a ranking of relevance or intensity; occupations are grouped simply according to their discipline.

■ Electrical engineer/technician	■ Motor vehicle engine tester
■ Mechanical engineer	■ Motor vehicle engine inspector
■ Sensor engineer/technician	■ ICT application developer
■ Automation engineer/technician	■ ICT application configurator
■ Mechatronics engineer/technician	■ ICT network engineer
■ Robotics engineer/technician	■ ICT intelligent systems designer
■ Application engineer	■ ICT system developer
■ Microsystem engineer	■ Software developer
■ Instrumentation engineer/technician	■ Embedded systems software developer

■ Photonics engineer/technician	■ Industrial mobile devices software developer
■ Optical engineer	■ Mobile application developer
■ Optoelectronic engineer/technician	■ 3D modeller
■ Industrial engineer	■ User interface designer
■ Industrial robot controller	■ User interface developer

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

- 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 with the automotive industry 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 certain 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, this review also takes in 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 the automotive sector:

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

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

A similar analysis could also be extended in principle to the other ISCO groups. Among which, 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, the big data analysis failed to reveal 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 from a remark about the need for a change in the mindset of the relevant actors, especially 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 did not emerge from the list of professions or from the interviews could indicate a strong focus within the automotive sector on the growth of technical profiles rather than managerial and sales/services positions. The high relevance of technical professions confirms the continuity of the sector with regard to the traditional profiles on which the attention of stakeholders is most focused, in terms of both innovation and the upskilling of job profiles. Indeed, the new technologies described in Chapter 4 are changing the production process and also the products themselves, but the main characteristics of the products from a business perspective (selling, import/export, accountancy, marketing, management, dealing with suppliers, etc.) are not affected: an electrical car or a self-driving car will be brought onto 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 roles are likely to be in demand. One can achieve this by looking at the skills listed for each occupation in ESCO. This is a straightforward exercise (e.g. robotics professionals – either engineers or technicians – must know how to assemble robots, monitor robots, perform test runs, record test data, etc.). The process is illustrated in Table 5.2.

TABLE 5.2 OCCUPATIONAL SKILL NEEDS RELATED TO A TECHNOLOGY: THE EXAMPLE OF SENSOR CONTROL SYSTEMS

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 reveal a deeper level of detail, are less well covered. Additionally, the competence level required (e.g. how deep is the required knowledge of/ability in sensor devices 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 the automotive sector may result in a demand for people to work in jobs or occupations which are new and not listed in ESCO, ISCO or other job classifications.

To address the limitations 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 (the most frequently recurring terms found in patents) the corresponding Wikipedia page was downloaded using web scraping. Reversing the strategy, it was then possible to provide a more in-depth analysis of the specific skills that will be required in various technical jobs (as shown in Table 5.3). 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 the robotic application.

TABLE 5.3 EXPANDING OCCUPATIONAL SKILLS DATA PROVIDED IN ESCO: THE EXAMPLE OF SENSOR CONTROL SYSTEMS

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 runs	Temperature sensors
	Read engineering drawings	Image sensors
	Record test data	Monitoring sensors
	Set up automotive robots	Etc.

It is important to note that not all of the topics/technologies which emerged from the patent analysis were matched to ESCO competences and occupations. For example, the technology related to charging stations (for electric vehicles) did not find a direct match (incidentally, one of the interviewed companies specialises specifically in charging stations). This 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 also be extracted automatically from online job postings, i.e. through web scraping. It was possible, for instance, to search for all job advertisements which mention ‘charging stations’ (for this task the global employment website Monster.com was used) and extract details of the occupations where this technology is mentioned. Since this approach leads to results which cannot be readily cross-classified with standard occupational classifications (e.g. ESCO or ISCO), it has not been pursued further in this study, but Table 5.4 illustrates the possible outcomes using the example of charging stations.

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

As clarified in 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 various technologies) and the competences they must possess are very specific.

TABLE 5.4 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

Discussions with stakeholders and companies revealed the existence of two trends:

1. a tendency to be vertically specialised in a particular technology or area but having the capacity to apply it transversally over different jobs, including a horizontal knowledge of many disciplines (a characteristic defined by companies as a 'T-shaped' profile – some even require a 'comb-shaped' skills profile, i.e. possessing a high level of expertise in 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 recurring theme touched on by the interviewees concerns the importance of the technical medium-skilled profiles within companies. The increase in technological complexity in this sector and in the automation levels of the production process is also expected to heighten the need for qualified resources in the automotive industry. Accordingly, a new segment of 'grey-collar' workers is emerging, so called because they are required to have more technical expertise than the average blue-collar worker. While retaining sophisticated manufacturing hand-skills, grey-collar workers are increasingly called upon to navigate technology-rich environments (e.g. including automated guided vehicles) and have to handle issues that emerge on the shop-floor. Professions will change due to digital transformation, so that more and more blue-collar workers will become 'grey-collar workers' (e.g. welding operators will transform into managers of welding robots). The composition of the workforce will also change accordingly: the number of low-skilled workers will fall in favour of a substantial rise in medium- (and high-) skilled workers.

This transformation will require a fundamental change in companies' organisational structures and human resources strategies. Up to now enterprises in the sector have been focusing on high-skilled employees, but without instigating proper training, ensuring the diversification of duties and enabling cross-pollination with workers on the production line, businesses 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 to upskill their blue-collar workers. According to the interviews, such training is also required because people exiting the education system lack the appropriate skill sets to become grey-collar workers straightaway.

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

Ranking occupations according to potential demand

In the case of technology-related occupations or jobs, it is possible to use the data mining results not just to list occupations but also to estimate their comparative 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:

- its technological transversality, i.e. the importance of the occupation grows if it includes skills related to more than one technology or topic;
- whether 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:

$$\text{Importance of Job profile } j(y_j) = \sum_{i=1}^{m} \mathrm{T}_{ij}\mathrm{E}_{ij}\mathrm{W}_i$$

Where:

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

$$\mathrm{E}_{ij} = \begin{cases} 1 & \text{If technology/topic } i \text{ is linked to job profile } j \\ 0{,}5 & \text{otherwise} \end{cases}$$

$$\mathrm{W}_i = \text{Importance of the technology/topic } i$$

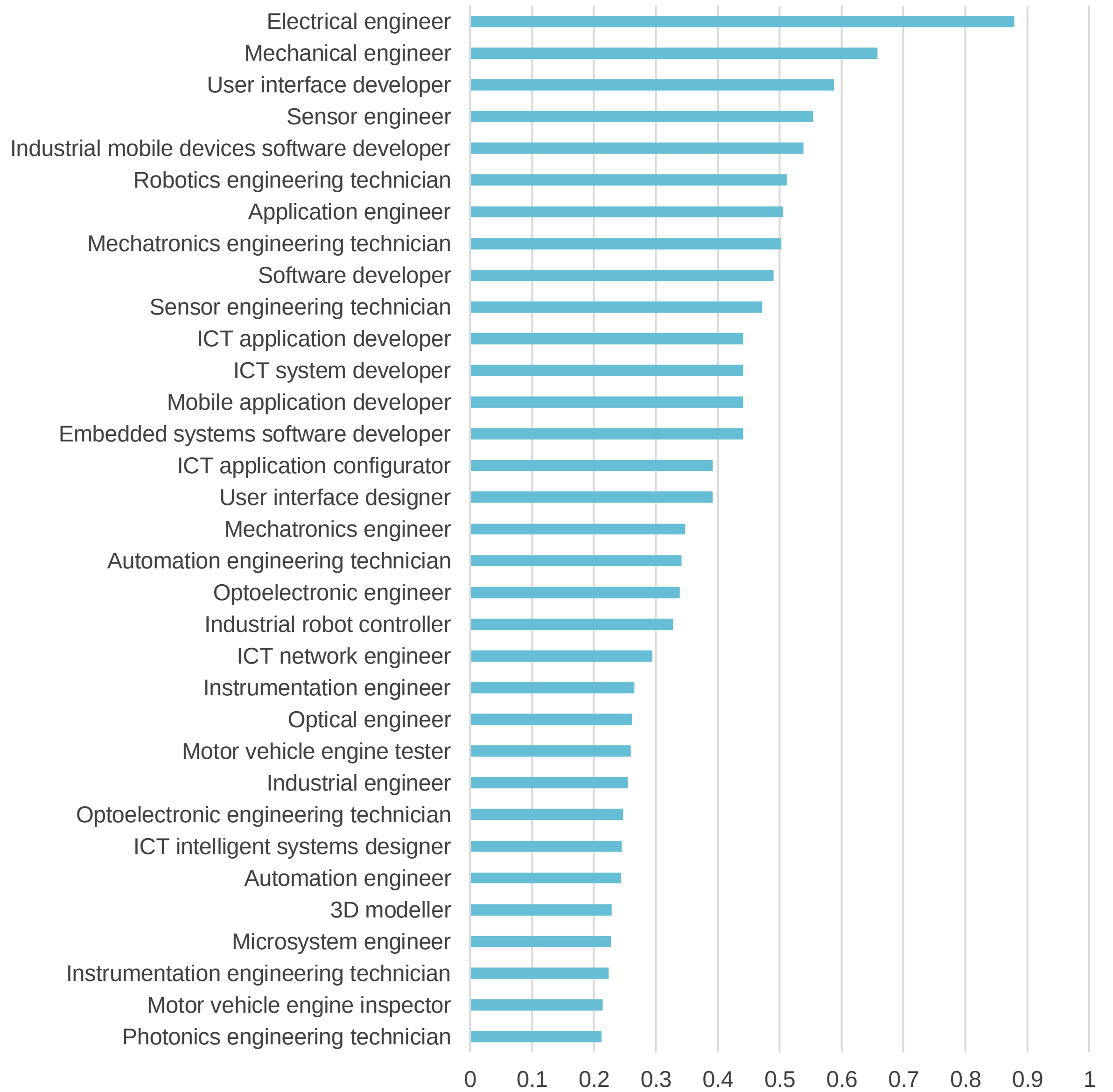
The values of T_{ij} are derived from the analysis in Table 4.1, the values of E_{ij} are based on a sensitivity analysis[26], and the values for W_i stem from the intensity of the signal for the given technology developed from the patent analysis (see Section 4.3 and Figure 4.5). Once the scores have been calculated for all the 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 in Figure 5.1 (relevancy scores are normalised and cut above 0.2). The ranking is indicative of which job profiles are of potential interest, though far from a precise ordering. A full-scale analysis of the demand for jobs would require a deeper investigation, using a range of different

[26] 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 various 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.

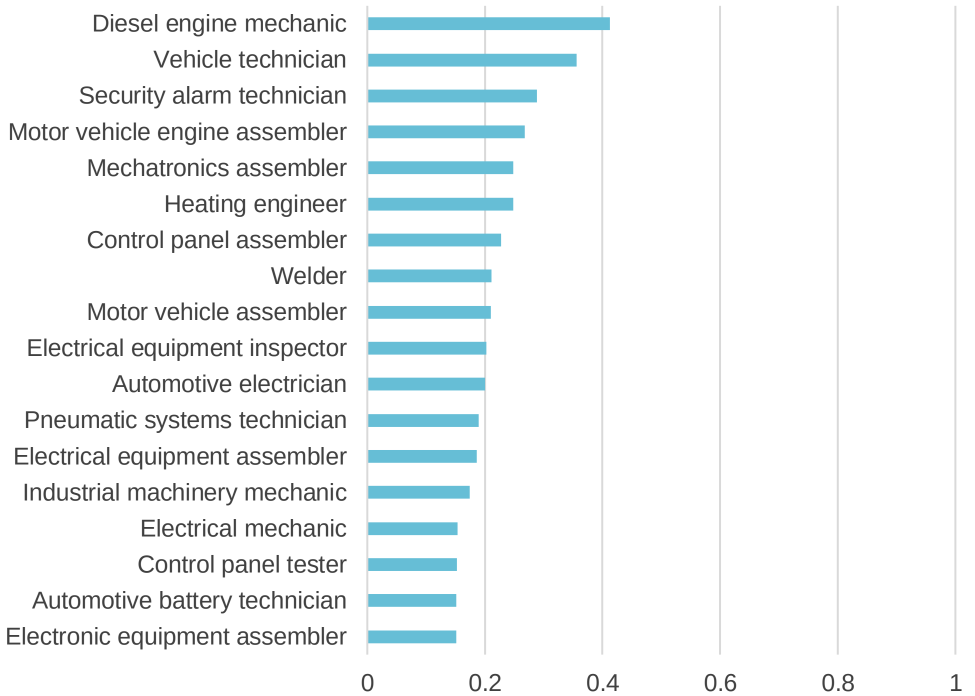
approaches, and is beyond the scope of the present study. Yet this review provides interesting insights: from the plot it is clear that there will be a high demand for electrical engineers, mechanical engineers and user interface developers, etc., while occupations such as 3D modeller will still be needed in the future but perhaps less so than other occupations.

FIGURE 5.1 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 commentary regarding the meaning and the limitations of the ranking. The output is shown in Figure 5.2 (relevancy scores are normalised and cut above 0.15). In general, these roles receive a lower score than professional occupations, yet it is still possible to assess their comparative relevance – diesel engine mechanics seems to receive a higher ranking than for example automotive electricians.

FIGURE 5.2 RANKING OF RELEVANCE FOR MEDIUM- AND LOW-SKILLED OCCUPATIONS FROM ESCO (ON THE BASIS OF THE TECHNOLOGIES THEY CORRELATE WITH)

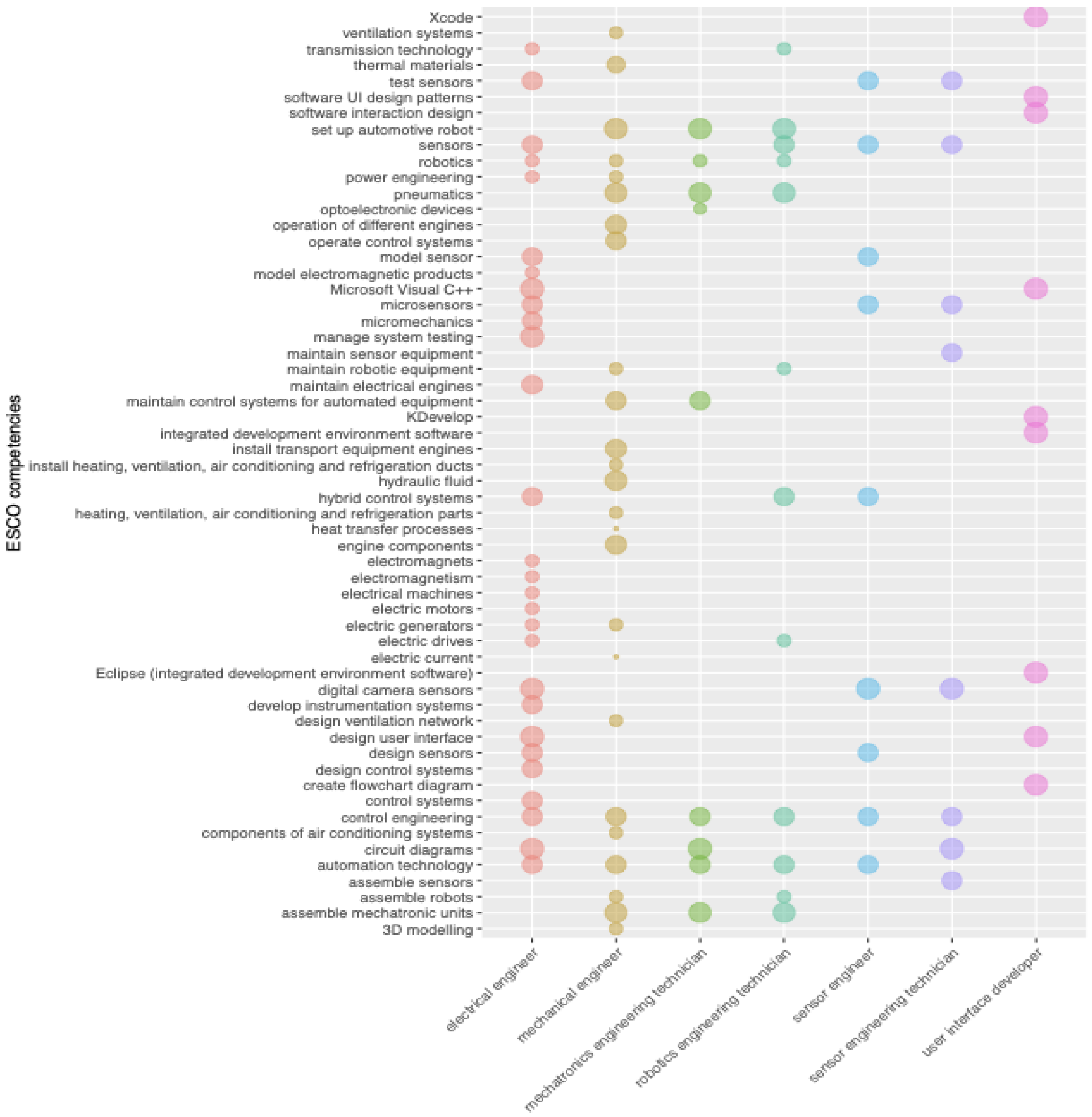


In addition, it is also possible to take a more detailed look at each occupation by analysing how they differ from one another based on which ESCO competences they are connected with. For instance, taking the posts of electrical engineer, mechanical engineer, user interface developer, sensor engineer, robotics engineering technician, mechatronics engineering technician and sensor engineering technician, a bubble chart can be formulated to visualise which skills or sets of knowledge are associated with the various occupations, and how important these are based on the technology/topic with which they are connected.

In Figure 5.3, the horizontal axis lists the seven ESCO occupations, which are matched on the vertical axis with the competences ESCO ascribes 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.

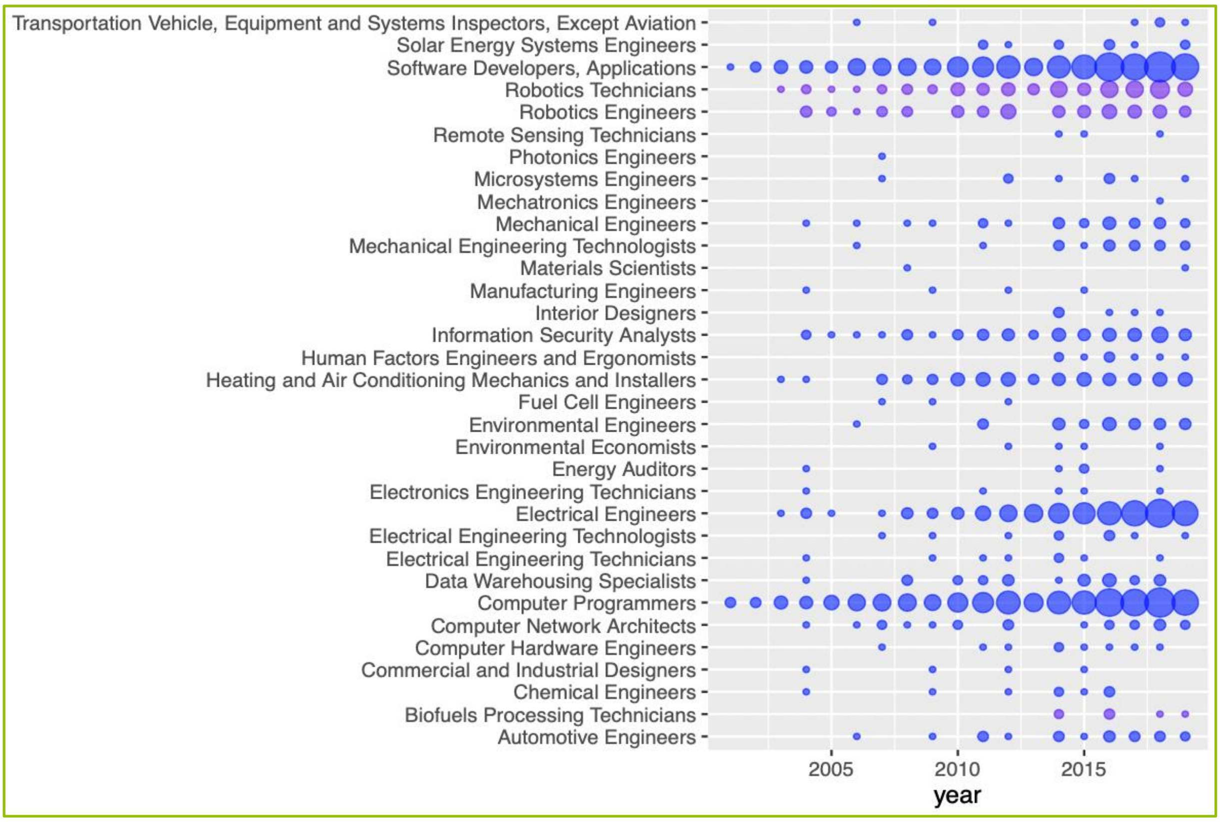
This graphic shows the distribution of competences across occupations. For example, it reveals that to work in the automotive sector the electrical engineer needs to have skills related to automation technology, circuit diagrams, electric drives, generators, motors, electromagnetism, how to write code in C++, how to design sensors, how to manage system testing, etc. On the other hand, the mechanical engineer has competences that are mostly linked to the functioning of engines, control systems, robotics, ventilation systems, and 3D modelling.

FIGURE 5.3 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 Figures 5.1 and 5.2 can also be applied to scientific papers and O*NET to obtain the results shown in Figure 5.4. This chart has a similar purpose to Figures 4.4 and 4.5, but instead of aggregating all the 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 particular year.

FIGURE 5.4 O*NET OCCUPATIONS AND THEIR GROWTH OVER THE YEARS IN THE AUTOMOTIVE SECTOR IN TURKEY (AS EXPRESSED BY THEIR OCCURRENCE IN SCIENTIFIC PAPERS)



Note: According to O*NET, the colour based scale of the risk of automation goes from blue, that corresponds to an absence of risk, to red, that represents a high risk of future automation. Therefore, professions that are represented with purple dots have a not zero-risk of being automated but such risk is still negligible (its score is less than 10 out of a scale of 100).

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

O*NET also provides information on the degree of automation associated with each occupation (i.e. the extent to which a job can be substituted by a machine), with blue dots indicating those jobs with no propensity for being automated and red dots indicating a high potential for automation. In Figure 5.4, the purple dots indicate very low (and negligible) risk of being automated, while the absence of red dots means all occupations having a low risk of being automated. It should 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 competences. In this section we review the feedback from stakeholders and companies, which confirms the results of the text mining.

The growing trend for smart vehicles explains the fact that some of the most required profiles are user interface engineers and technicians. Partly due to the digitalisation of production systems, all professions related to IT seem to be increasingly requested, for example: software engineers, embedded software developers, internet of things developers and specialists, algorithm developers, network builders, software installers, artificial intelligence scientists and cybersecurity specialists. Given the transversal nature of software, the demand for system integrator engineers will also rise, while a significant subset of occupations specifically concerns data acquisition and management: data scientists and analysts, data transmission experts and warehouse engineers. The companies surveyed for this study reported that qualified professionals in these areas are not only in high demand, but also very difficult to find, either due to overall scarcity or because the automotive sector is not attractive to the relevant jobseekers, who prefer to move abroad or work in other sectors, such as finance or telecommunications.

The other big trend that Turkey's automotive sector is investing in is electric vehicles, involving associated occupations such as electrical engineers, advanced vehicle electronic experts, electric maintenance specialists and control engineers.

Since all vehicles will continue to need mechanical and structural components, more standard sectoral occupations, such as mechanical engineers and mechanical design engineers, simulation engineers, structural analysis engineers, system engineers, and design homologation and test engineers, will also remain in great demand, and expert-level posts in these areas are reported to be difficult to fill.

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

A particular category that was not captured by the text mining (probably because it is not present in ESCO) but is relevant for certain companies is that of expert in coating technologies, a specialism that is not well known in Turkey and has proved hard to find.

Another observation which came directly from the interviews was related to the difficulty of recruiting and retaining 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 days and shift work covering holidays and nights. Thus, many experienced engineers and technicians prefer to avoid this line of work or require very high salaries which are difficult for some companies to manage.

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

A final remark must be made regarding the place of non-technical occupations in companies. Sales, business development and customer care staff will of course always be needed in enterprises, as will managers. Notably, the advent of technological changes will not require such personnel to possess new technical skills; rather, they will have to adapt in terms of mindset and attitude – understanding the new challenges and opportunities of Industry 4.0, being open to evolving their business models, and basing their decisions to a greater extent on data-driven evidence. Additionally, managers and project executives may need skills in organisational methodologies such as TRIZ and Kaizen[27].

Comparing the results from the interviews and those from the text mining, there is substantial agreement between these two sources of information. Furthermore, 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 in the sector.

5.2 Emerging skills 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, were mentioned during the focus group discussions. The text mining discussed in Section 5.1 also highlighted such occupations. These roles can be considered as new emerging professions, and further examples can be expected to materialise in the future, from industrial big data scientists to human-robot interface specialists.

A relevant point to add is that some occupations, namely those that are multidisciplinary in nature or positioned at the boundary between two disciplines, such as mechatronic engineers, are deemed increasingly important in terms of managing complexity and changing working environments. Companies need professionals who can create a bridge between different functions across the value chain, and these kinds of profiles have interactions with different technologies or competences. New types of system integrators (not just ICT ones) will also emerge.

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

Taking the discussion further, according to interviews, the digital education and digital 'literacy' of all employees will be a main driver across all sectors in the future. Becoming a digital employee does not mean having to become a computer scientist; rather, all members of the workforce, from economists

[27] TRIZ (the Theory of Inventive Problem Solving) is a systematic approach for understanding and solving any problem and a catalyst for innovation and invention. Developed by a Russian engineer, it is a technique that fosters invention for project teams who have become stuck while trying to solve a business challenge. It provides data on similar past projects that can help teams find a new path forward. Kaizen is a term that refers to on-going or continuous improvement. Coming from the Japanese philosophy and first introduced by Toyota back in the 1980s, it is statistical process control that improves quality in business, where employees are empowered to suggest ideas that address common problems so that they do not reoccur.

to engineers, need to be digitally literate, i.e. able to understand the basic principles of robotics and coding (a sort of 'third language' alongside their native tongue and English).

A new cluster of occupations that will emerge in the future will be that of 'translators', not in terms of language but in relation to technologies, and between machines and people. These professionals will understand the logic of a machine/data/software process and be able to transmit this to other people, as well as translating user needs into instructions for technicians and developers. New jobs will also appear that involve understanding process needs in order to translate them into robotic language. Examples of such new roles include industrial big data scientists, robotics specialists and digital mentors. A novel type of specialisation for the data scientist could be focusing on human behaviour rather than on numerical data: for example, reading from statistics and trying to detect patterns, such as customer or selling patterns, and transforming the value proposition accordingly.

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

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

In conclusion, as a result of the use of technologies and automation most jobs will change. People at every level will need to nurture their competences, not only to cope and survive in the changing world in which we live, but also to increase the added value of their work and attain better working conditions.

Skills obsolescence

New technologies will have a significant impact on the automation of many tasks, leading to a redefinition of the activities and occupations related to various job profiles. All the interviewees agreed that the most routine tasks/jobs are expected to disappear and be replaced by automated processes. In particular, manual assembly workers, machine operators and logistics operators (e.g. warehouse managers or forklift drivers) will be substituted by robots; visual and quality controls will be carried out by cameras and sensors coupled with AI instead of people conducting manual controls; and in finance and administration processes some obsolete activities will also be automated thanks to AI. Even in engineering and management roles, most of the routine jobs will be undertaken by algorithms and through using machine learning approaches. According to one company, even certain specialisations such as structural engineering will become obsolete.

As a consequence of automation, some professions will disappear altogether. The numbers of production line workers are already decreasing, as are call centre operators and truck drivers; in general, low-skilled occupations are expected to diminish in the coming years.

On the other hand, many occupations will not be eliminated but will rather change in nature: if manual workers on the production line disappear, they will be substituted by technicians working in, for example, electronics, mechatronics, sensors and data programming, tasked with managing troubleshooting in their respective areas, programming robots and cobots, or repairing cameras and sensors. Already blue-collar workers are working on CNC programmes and models so that in the future the physical work involved in certain occupations will be converted by IT into automatic tasks, still guided by human expertise.

The technical skills of engineers and managers will be more related to creating strategies and dealing with human relations rather than analysing large amounts of data and undertaking repetitive tasks. Workers' skills should be increased with the use of software, deep learning and machine-learning algorithms. In principle, grey- and white-collar employees could collaborate more easily in the areas of design and innovation. Given the very low numbers of grey-collar workers in current context, many companies need to train their blue-collar staff in technical and creativity skills to make this collaboration possible.

As a complementary information source, the skills classification system O*NET provides expert-based analysis of the likelihood of each occupation being replaced by machines – a breakdown which other occupational classification systems do not provide. All the profiles which emerged from the analysis that were pertinent to this study involved 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 by machines in the future. This was confirmed in the interviews with the companies.

Merging the results of the analysis with the outlook of the companies working in the automotive sector, a significant fall in employment levels is not expected, due to the difficulty of introducing complete automation within these businesses and because of the upskilling of already-existing job profiles. Even if some professions are likely to disappear in the future, the tasks that need to be carried out by employees will be redefined. Enterprises talk of upskilling and repositioning within the company, not of drastic reductions in the workforce; rather than firing current blue-collar manual workers and hiring grey-collar staff, it is more likely that workers will be trained to acquire more competences ('It is not about replacing people but giving them new responsibilities').

According to the interviews, attitudes and soft skills may be as important as technical skills for navigating the ongoing changes that will shape the sector. Behavioural skills such as flexibility and a willingness to learn will help people to meet the challenges that lie ahead.

In conclusion, the companies agreed that various positions will become obsolete as a consequence of the automation of a number of tasks. However, while some companies believed that the overall level of employment will stay the same, as new positions will also be created, other companies thought that the total number of employees will decline slightly.

5.3 The role of soft skills

Due to the difficulty of assessing soft skills, they are not well defined in the literature. Thus, everyone tends to understand and interpret such competences differently, while at the same time they are also continuously evolving. Various terms are used to describe these types of abilities, such as transversal or soft skills, personality traits, character skills, 21st-century skills, life skills, key competences, new mindsets or social/emotional skills. Moreover, these skills often relate to individuals' personal attributes, and refer to, among other things, teamwork, communication, initiative, sociability, empathy, collaboration, emotional control and positivity, open-mindedness, willingness to learn and to change, flexibility, curiosity, innovation, creativity, entrepreneurship, resilience, planning/organisation, responsibility, persistence, etc.

Despite the difficulty in defining and assessing soft skills, almost all the company representatives reported that they are crucial factors in the hiring process. In fact, in some cases, they are regarded as highly as technical specialisation. Among these competences, problem-solving, analytical skills, design thinking and creativity are seen as essential, since the enterprises of the future will be even more firmly based on innovation and the ability to think outside the box. Moreover, flexibility, resilience and agility are considered fundamental in facing the rapidly changing business environment and adapting in a reactive manner. The companies interviewed also highlighted the motivation to learn new things as well as the ability to self-educate and learn on the job as important components in preparing for change.

On top of these skills, emotional intelligence and communication skills were mentioned as other relevant abilities, especially for leadership roles and even for technical profiles such as engineers. Teamwork, project management and self-management were also viewed as important behavioural competences. In a sector that is becoming increasingly globalised, the ability to deal with multicultural environments will be critical for companies. All the above-mentioned skills will be even more useful in the future, as more people work remotely, or work as freelancers or on a project basis, requiring a high degree of flexibility and an assignment-oriented approach.

Since more sectors are collaborating and combining with each other, an increasing need has emerged for a mindset that can handle multi-tasking and respond well to a multidisciplinary environment, thus enabling employees to obtain knowledge from different areas and on various topics, and work in mixed teams. Finally, in the view of the companies surveyed, all workers will have to possess digital skills to a certain degree. People will need to follow technologies and be open to change. Moreover, they should be prepared to take decisions using a data-driven approach, and be competent in handling and talking about data.

5.4 Main findings

- The two main categories of job profiles growing in demand are: technical professional and associate professional occupations; and trades workers and machine operators. Both groups are affected by the current technological changes in terms of products (the shift towards electric cars and autonomous vehicles) and production techniques (Industry 4.0, automation, additive manufacturing), and as a consequence need to increase the number and variety of skills they can call on – both soft skills (e.g. problem solving, flexibility and resilience) and technical competences (e.g. digitalisation-related skills).
- A new class of employee is emerging – grey-collar workers, so called because they are upskilled blue-collar workers with more technical expertise. As a result, the composition of the workforce will change: the number of low-skilled workers will fall in favour of an increase in medium- to high-skilled workers.
- New jobs are emerging that are not found in classifications such as ESCO. This is due to the rapid pace of technological change and the high level of specialisation this brings about. New profiles appear fluid, reflecting the trend towards multi-disciplinarity and the need for employees to have integrated knowledge of various technologies. The worker of the future will need a wider range of skills and competences, the ability to mediate and adapt to new situations and roles, and the willingness to work across disciplines.
- It should be recognised that the changing work landscape is not just about the creation of new job profiles. It is apparent that many existing roles in the automotive sector – such as welders – will survive, but their task content and skills sets will evolve as a result of technological changes.

- Soft skills are regarded as highly important by companies and stakeholders (especially resilience, flexibility, problem solving and creativity). Thus, the debate on future skills needs focuses not just on technical competence but on a mix of practical and soft skills.
- For most of the interviewed companies operating in the international arena, the lack of or limited English-language knowledge among their employees is a common challenge.
- Most of the companies believe that the overall level of employment in the sector will not decrease as a consequence of the introduction of new technologies, but that the decline in labour-intensive occupations will be compensated for by an increase in higher-added-value roles.

6. SECTOR INITIATIVES TO MEET CHANGING SKILLS DEMANDS

KEY ISSUES

- How the changes caused by the introduction of technologies affect 'skills utilisation' and working conditions in the sector
- The ways in which businesses meet their new skills needs (new hiring, retraining, etc.), and the existing joint initiatives and links between companies and education and training providers
- Whether the education and training system is adapting to the ongoing changes and whether it provides adequate answers to companies' needs in terms of competences and skills

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

6.1 Limiting factors for adopting new technologies

Companies were asked which factors were limiting the adoption of new technologies and the development of their business in general. Most of the companies identified a shortage of skilled workers as the main factor inhibiting investment. Furthermore, macroeconomic instability, leading to fewer investments, coupled with the excessively high costs of technologies, were also seen as hampering the introduction of innovative solutions. On the other hand, globalisation and falling levels of international trade were not widely considered to be an issue by the companies.

With regard to the shortage of skilled workers, this applies to both medium and high levels of skills. The shortfall in skills is not related to the reputation of the automotive industry, which in Turkey is relatively good; rather a key reason is the fact that educational institutions do not provide sufficiently qualified young people. Educational programmes are not up-to-date, nor are they aligned with the trends in new technologies and the needs of companies (e.g. mechanical engineers in some cases are reported to lack knowledge of statistics and/or analytic skills).

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 stronger collaboration between universities and the private sector is required in order to align skills with business needs and prepare students for a future working in industry. One of the greatest challenges in the education system seems to be that teachers have insufficient skills and are unaware of industry needs, which has an adverse effect on students' outcomes. In addition, there is a high turnover of teachers in the education system, so a further priority should be maintaining staffing levels over a period of years in order to provide continuity.

Regarding the lack of skills that may recur in the future, this problem is also related to the changing speed of manufacturing and OEMs. Educational institutions need to be aligned with the pace of change in order to connect the curriculum in schools with the real situation inside the plants. Joint workshops between representatives of OEMs and vocational schools are already held, but the frequency and depth of these events are perhaps insufficient.

In addition, the shortage of relevant expertise is expected to become an even greater problem over the coming years. People with the skills to take on some of the most sought-after posts (e.g. ICT-related profiles, data analysts and data mining experts, etc.) are more likely to prefer sectors that are perceived as having more stimulating work environments than the automotive industry (e.g. IT, telecommunications, banking, finance, etc.) (as indicated in the interviews).

Another risk is the issue of highly skilled individuals emigrating abroad. In line with the currently observed trend of steadily increasing emigration rates among Turkish engineers, other experienced and highly skilled workers may in future leave the country to find better working conditions or career paths abroad, thus exacerbating the shortage of qualified candidates to fill white-collar roles.

It was also claimed in the interviews that most new graduates prefer to work in an office setting rather than undertake difficult physical tasks such as maintenance, and, as a consequence, they do not engage with the real work of the process.

In addition, companies seem to experience a high turnover of blue-collar manual workers, especially in areas of the country where agricultural production is important. Low-skilled workers often leave automotive plants, either to work in the agricultural sector (at least in certain locations) or for other companies, mainly because there is not much difference in salary between jobs in industry and farming. In addition, according to the interviews, workers' loyalty to the company they work for has been decreasing in recent times.

Another issue preventing innovative change from taking place is the excessively high costs of new technologies, a factor that is exacerbated by macroeconomic instability. Due to market fluctuations, the number of orders coming in does not provide a secure basis on which to plan major funding. A more stable situation regarding the total number of orders received will help companies to make greater investments. Additionally, macroeconomic instability and political issues also have negative consequences in relation to foreign funding (as witnessed recently with Volkswagen suspending a planned investment). In the specific period during which the interviews were conducted, the companies' views were also affected by the Covid-19 pandemic. Indeed, one common difficulty the companies face is the cancellation of orders and the related downsizing of production activities. The difficulty of importing raw materials (which are generally sourced from East Asia) has also reduced their production rates.

Finally, as revealed by the interviews, resistance to change may also act as a limiting factor. Actors along the supply chain should be aligned with the need to introduce new technologies; however, innovation does not always seem to be clearly understood or welcomed by all the actors involved. Moreover, global OEMs prefer to work with international suppliers in their technological area, leaving local suppliers unable to invest in technology dealing with production aspects only. Willingness to change is a crucial factor, without which difficulties in investing in new technologies and developing activities can sometimes arise. A reluctance to embrace innovation can manifest itself both at a managerial level (translating into a lack of investment and foresight) and at the workers' level (manifesting as a fear of being replaced by robots and automation).

6.2 Recruitment strategies of companies

In general, for many automotive companies in Turkey, vocational schools, universities, and academic and industry collaborations are all important sources for finding qualified employees. According to the interviews, recruiting strategies may vary according to the level of employee profile required. The most common strategy to obtain the required skills is hiring new workers who have the right kind of expertise. As reported in the interviews, in some cases, high-skilled workers are recruited via head-hunters and professional networks; medium-skilled workers through career portals and existing employees' contacts, and low-skilled workers using newspaper advertisements, social networks and the public employment agency (IŞKUR).

For some companies, pursuing collaborations with universities, research centres and other institutions is the main strategy for meeting their high-skilled staff needs, especially in relation to engineering and managerial roles. Forging links with universities is favoured by companies because of the trustworthiness of these institutions and the experience they have in education.

A common approach taken in recruitment is the three-step interview: first, there is a human resources selection based on general competences, followed, secondly, by a technical interview, and then, thirdly, by a more conversational interview with management, intended to elicit the personality and soft skills of the candidate. More structured companies have a human resources manager and apply different recruitment policies for different job levels. The general path taken derives from the definition of the company's strategic plan: which products and technologies should feature in the company ten years from now? As a consequence of the plan, the human resources department prepares a gap analysis chart for each job title, considering both engineering and management capabilities. The company thus manages its recruitment and training programmes according to the competences gaps shown in such charts.

It is relatively rare for companies to try to obtain the appropriate practical experience by hiring people from abroad. However, this strategy was observed in one company working on forging processes, knowledge of which is not widespread in Turkey.

In most cases, after recruitment, further training programmes are provided for new graduate engineers, in both managerial and technical competences, and also to impart more operational and focused skills relevant to the companies themselves. In addition, internal training courses are also arranged as a way of sharing the knowledge of more senior and competent employees. As mentioned previously, the automotive sector is well organised through strong employers' associations. These sector organisations (OSD, TAYSAD, ODD, OYDER) also have excellent training programmes, which are run on a regular basis and are open to all members. This is a big advantage for the sector in Turkey, as employers here can obtain many services and training opportunities from their associations.

One such example is the high-quality training programmes which have been organised and delivered by TAYSAD for 15 years on topics requested by their members[28]. The subjects of these courses are determined by conducting a survey among the organisation's members every few years, with the topics requested subsequently included in the training plan. Like TAYSAD, OSD is very active on its

[28] See the related website page of TAYSAD at Eğitim/Etkinlik (taysad.org.tr). TAYSAD is also one of the key members of the European Cluster Initiatives, which includes training, www.clustercollaboration.eu/cluster-organisations/automotive-suppliers-association-turkey-taysad

members' behalf, as is the Turkish Employers' Association of Metal Industries (MESS). The latter organisation arranges special training programmes for digital transformation and competence development in companies through its Technology Centre and online platform[29].

6.3 Training strategies of companies

As noted in the interviews, a common perception is that, due to the fast pace of technological change, gaps in competences will always be present, even if the educational system (both at the university and secondary level) makes an effort to adapt to the sector's new emerging needs. Hence many companies (particularly large and medium-sized enterprises), as well as sector associations, take the initiative in filling such gaps through providing training programmes. The issue of improving skills for white-, grey- and blue-collar workers is a common problem for the industry in Turkey. To take TAYSAD as an example again, it organises meetings on the topic twice a year, which are attended by more than 400 companies in the sector, including international ones.

According to the interviews, company managers are sometimes responsible for suboptimal training strategies. In reality, every manufacturing company has a business plan and sets a budget for training activities. However, in terms of overall spending, companies tend to spend less on training as it is seen as a cost driver. It was therefore suggested in the interviews that managers should change their attitude and see training activities as an investment in the future of the company.

One of the most frequently recurring comments made by company representatives was that during their time at university, students are not taught how to learn on the job. Some mechanical engineers see a plant for the first time after graduating. During internship periods they prefer to focus on office duties and tend not to engage with the work of the production line. The after-hiring adaptation of new recruits costs companies too much in terms of time, money, effort and resources. From observations made in the interviews, it takes approximately five years to turn a mechanical engineering graduate into a 'real' mechanical engineer.

Students need to acquire both technical and soft skills, and above all they should 'learn how to learn' as they graduate with only theoretical knowledge. The causes for this are to be found in the educational system: professors and lecturers at universities lack experience of the real-world needs of the sector (according to the interviewees).

Many strategies have been adopted by companies to improve this situation. The most common solutions for training people and reducing the skills gap are providing internal (in-house) instruction or buying tuition from a variety of external actors, ranging from universities and research institutes to engineering consultancy companies, depending on the budget or topic.

Training can be carried out by staff within the company in cases where there is a highly experienced person in a given area of expertise. According to the interviews, learning-on-the-job strategies are commonly adopted: new hires are often supported by expert members of staff, who can follow their progress in the execution of various activities and share their know-how. Job rotation programmes for the internal workforce are also sometimes adopted. Some companies have further developed an internal expert community regarding engineering issues.

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[29] For more information, see www.messteknoloji.org.tr/

Businesses are also interested in soft skills and try to organise training for them too. One of the companies surveyed has developed a structured training programme specially dedicated to three different skills sets: emotional intelligence, adaptability quotient (AQ)[30] and digital intelligence. The adaptability programme is important for empowering employees to face future challenges. The agility issue, which is also addressed by the programme, is split into a number of major topics: mental agility, i.e. analytical thinking ability, with a focus on listening and finding appropriate solutions; people agility, because team management is important, especially for remote working; change agility, for example the capacity to understand the relevant strategies and deal with uncertainty; and also result agility – training people to develop methods to change solutions and take the initiative. A further component, digital intelligence, covers such subject as digital security, how to become a digital citizen, using social media appropriately and communicating effectively through digital channels.

According to the interviews, the use of open source online training opportunities (web-based) is a solution that has already been adopted by some companies and is expected to be further taken up in the future, due to the increasing diffusion of smart working.

Finally, many companies have also organised, or are planning to set up, their own internal academies or training centres in order to fill various skills gaps: once students have completed their formal vocational schooling, the company then teaches them about technical issues and helps them to develop competences in soft skills like resilience or agility. Regarding the future, with the aim of 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 training centre to cover the entire internal workforce. This would allow companies to organise flexible and customised internal academies to share know-how within their plants.

6.4 A final word on the findings

The sections above presented the main initiatives and strategies adopted by the companies to meet the sector's changing skills demands (based on the interviews). Due to the limitations of this report, conducting a comprehensive review of the skills supply system and public education and training was not possible. The ideal scenario would be to have a follow-up study comparing the skill needs of companies, as expressed in the interviews, with the provision of skills supply within the education and training system. This section refers to a number of other initiatives regarding skills demand and supply in Turkey, particularly in the manufacturing sector, and attempts to develop some recommendations related to meeting the needs for specific skills in the automotive sector.

Turkey has made substantial progress in human capital development, but as far as most education and training indicators are concerned, wide gaps persist between Turkey and comparable countries in the EU and OECD (ETF, 2019b). The main human capital challenges in the country comprise: further improving the access to and quality of initial education and training; providing career opportunities for a large youth population; and reskilling and upskilling the adult workforce, including a huge number of refugees (ETF, 2020b). The relative importance of adult learning is expected to increase as reskilling and upskilling for new jobs becomes more crucial in ensuring employability, while adults in Turkey

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[30] Adaptability quotient (AQ) is a scientific measurement of adaptability in individuals and teams, first created by Amin Toufani. The concept was publicised through Toufani's lectures over five years at Singularity University and subsequently at Adaptability University, and is defined as 'the ability to realize optimal outcomes based on recent or future change' (see Adaptability University).

seem to be less prepared for the future than their peers in other countries. To date, Turkey has responded to the challenges posed by technological change through a number of policies and actions.

As the worker profiles and competences needed by companies are constantly changing, different types of employer surveys are conducted regularly to identify current and future skills needs in Turkey, both for the whole economy and for certain specific sectors. IŞKUR conducts such a survey annually with the support of the EU's Instrument for Pre-Accession Assistance (IPA funding). The results of the latest review in 2019 also confirmed the increasing demand for software developers, coders, ICT experts, data processors, AI engineers, robotics specialists, biomedical engineers, industrial automation technicians, hybrid vehicle experts, mechatronics engineers/technicians, drone operators, etc. (IŞKUR, 2019). In response to this, and within the framework of the 'Directive on the organisation of training for a qualified labour force to meet the needs of the digital economy', IŞKUR organises courses and on-the-job training programmes to upskill the labour force in line with the future occupational needs of employers.

According to the written information provided by IŞKUR, since 2015 one of the training fields covered has been the IT sector, including software and systems development and institutional resource planning. In total, 7 942 people benefitted from these training courses between 2015 and 2019. In addition, 'On-the-job training programmes on future occupations' began in 2018, with the duration of these courses increasing from three to nine months. The beneficiaries of this programme are young people aged 18–29, who are able to attend on-the-job training arranged in techno cities, R&D centres, design centres and businesses in the information sector. In total, 2 522 people participated in this programme between 2018 and May 2020 with respect to 25 occupations, including cyber security expert, cloud informatics specialist, game developer, animation programmer, information security expert, multimedia designer, digital forensic professional, industrial robot programmer, micro process designer, mobile software developer, social media expert, database analyst and database administrator.

Another recent skill needs analysis, conducted by the Technology Development Foundation of Turkey and focusing on high-skilled labour needs in the Turkish manufacturing industry (TTGV, 2020), confirms similar results to those revealed in this study. Out of the employers surveyed, 57% highlighted wide talent gaps in the current labour market, and reported that they find retaining highly qualified staff more difficult than recruitment. The most significant problems experienced are the limited supply of qualified human resources, difficulties in meeting employee expectations (e.g. in terms of management style, wages, working conditions), the insufficient and decreasing quality of the education system at all levels, a lack of systematic career guidance and planning activities, and the country's economic, sociocultural and political conditions (Ibid., p. 27). The most sought-after areas of expertise in the manufacturing sector are cognitive skills (creativity, innovation, analytical/ critical thinking), digital skills (digital literacy, online business aptitude, coding, software development), data processing, in-depth technical competences, problem solving, communication and cooperation skills, entrepreneurship and continuous learning, as well as the personal attributes to support this list (TTGV, 2020).

Within this context, the Turkish Vocational Qualification Agency (VQA) has created an occupational mapping of emerging skill needs and how the education system needs to respond (e.g. with respect to curricula). New occupational standards have been produced in the areas of autonomous systems, IT systems, artificial intelligence, digital industry and advanced manufacturing (e.g. for robotic systems operators). For example, the VQA is working with the Ford Otosan İhsaniye Automotive Vocational School to prepare occupational standards in the field of industrial robot programming (Doğan, 2019).

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 offers training in programming the industrial robots typically used in the automotive sector and tailors courses to the needs of local industry (OECD, 2017). The VQA has also revised the definition of 33 occupational standards and 27 vocational qualifications in the automotive sector (VET levels 3, 4, 5) (see Annex 2 for the full list). Since 2011, it has awarded 36 015 certificates of vocational qualifications related to the sector – the most common ones relating to auto mechanics, fitters, painters, electromechanics, sheet metal moulders and sheet metal and body welders.

Other good practices emerged during the meetings with stakeholders and companies with regard to fulfilling the future skills needs of companies. These initiatives 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 and libraries, as well as setting up social spaces. These examples of collaboration show that VET and higher education providers have a role to play in supporting the automotive ecosystem. However, sector representatives expressed a widespread concern that the education system finds it somewhat difficult to adapt to the fast pace of change in the automotive industry. It must be remembered that, today, purely job-related skills are no longer enough: secondary education, VET and higher education should strengthen transversal skills and key competences, while a comprehensive policy approach is required to achieve this (ETF, 2020d).

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

As this study has shown, in the automotive sector it is quite common for companies to set up their own internal academies and training centres, which is the case for most OEMs (e.g. the Ford Otosan Academy). Thus, companies try to compensate for skills gaps by widening their training strategies; for example, providing in-house learning and on-the-job instruction, buying training from external sources, or creating their own academies. A recent study by TTGV (2020) of the whole Turkish manufacturing industry also confirms this tendency, revealing that half of interviewed companies invested sufficient financial resources for human resources development and another 37% spent less than required. Nevertheless, more than two-third of companies (including at least half of small and medium-sized enterprises) organise internal training activities, from on-the-job training to mentoring and internal courses. This shows the importance given to skills development by the formal private sector in Turkey, but more cost-effective and innovative solutions are required to address the needs of smaller, less formal companies, for instance through utilising the public-private partnership approach.

The findings from this sector study indicate the need for encouraging and pursuing a further, closer collaboration between the world of business (companies) and education (both VET and higher education). The establishment of a number of industry-based taskforces awarding specific training certifications to teachers would be useful in maintaining the proper level of expertise within the profession. As an example, TAYSAD manages working groups in such topics as digital transformation and university-industry collaboration, as well as promoting international collaboration projects aimed at developing collaboration in new technologies funded by the EU's Instrument for Pre-Accession Assistance. At the same time companies need to encourage workers to pursue personal development with regard to technical issues and ways of making their output more efficient and distinctive. Employees at every level need to nurture their own competences as this will increase their added value. As with technical abilities, key competences and soft skills are becoming even more important since people's adaptability and willingness to learn are set to become foundational traits for the employees of the future. Acquiring such skills depends not only on VET and higher education provision, but also on the access to and quality of basic education (from pre-school to primary and lower secondary level).

Human capital is the primary variable in countries' development and innovation capacity and in their ability to adapt to future developments. As emphasised in the TTGV report (2020), the quality of human resources is key to enabling a large majority of the population to reach a 'critical mass'. It is possible to talk about the need for an increase in quality at every level of education. The findings of this report, together with other similar studies referred to here, will feed the debate about the changings skills needs in the Turkish manufacturing industries, including the automotive sector. They will help to raise the awareness of the key stakeholders, policy makers and practitioners with regard to ensuring that the education and training system is capable of preparing workers to embrace the new jobs and occupations emerging in the sector. Possible actions could include:

- increasing the quality of learning in basic sciences, especially mathematics and physics, throughout the course of the education system, from beginning to end;
- identifying specific gaps in the existing curricula of the VET and higher education system, as well as placing greater emphasis on core and soft skills in general basic education;
- prioritising students' acquisition of the most-needed cognitive, digital, foreign-language, communication and cooperation skills, regardless of the profession they will pursue in the future;
- increasing the focus of the education and training system on new emerging technologies (as identified above) and transversal technologies;
- creating learning units (modules) for the upskilling/reskilling of professionals and workers (covering low-, medium- and high-skilled jobs);
- incorporating work-based learning modules or initiatives across different education levels (including for higher education students);
- developing specific curricula and upskilling mechanisms for grey-collar workers, given the increasing complexity of their work and their growing relevance within companies' organisational structures;
- adapting pedagogical systems to enable learning to research, learning to learn and the acquisition of lifelong learning skills by students;
- the development of new qualifications by the Turkish VQA, in partnership with universities, VET providers and companies in the automotive sector;
- providing better career guidance and information about job and career opportunities for students and families, considering the specific characteristics of each sector;
- offering discrete mechanisms to support the transition of young people and workers from job to job, especially in the case of low-skilled workers;
- systemising existing good practices regarding human capital development efforts in the automotive sector;

- establishing more concrete mechanisms to enhance the collaboration between enterprises and education providers. This collaboration needs to be purposeful and entered into on an equal basis, rather than merely forming a consultation on paper regarding social responsibility for the sector, etc. This could take the form of specific Skills Strategic Partnerships Formats, such as the 'Pact for Skills' that was recently announced within the EU. The latter could be open to any type of sectoral organisation or association active in the field of education and training, as well as those bodies carrying out activities that have transversal applications across different fields.

6.5 Main findings

- There are various factors which may be constraining growth in the automotive sector. Most companies indicated a shortage of skilled workers as the main limiting issue in the interviews. One of the reasons for this is that educational institutions do not produce sufficiently qualified candidates for working in industry. Other considerations, such as the emigration of high-skilled workers and the comparatively low attractiveness of the automotive sector, also play an important role.
- The interviews with companies suggested that one problem related to skills mismatch is the speed of technological change: despite the difficulty of keeping pace with rapidly moving advances, educational institutions should be aligned with such developments and connect their curricula with the real needs of automotive plants.
- Based on the interviews, companies follow various strategies to meet their skills needs, ranging from recruiting new graduates from universities to posting advertisements on online job portals. Their recruitment tools change according to the level of skills/job profiles required.
- The sector has existing links with the educational system. At the same time, it seems that the educational system is unable to provide all the competences required by the automotive industry. After hiring, all new graduates, at whatever level, require on-the-job training (according to the interviews). Thus, automotive companies provide instruction, mentoring and coaching after recruitment in order to introduce new graduates to the job and the working environment. A closer collaboration between the education system – both universities and vocational schools – and companies is advisable.
- Companies try to compensate for the skills gap through various approaches, for example widening their training strategies by offering in-house learning and on-the-job training, or buying provision from external actors, such as private companies or universities. Moreover, it is quite common in the automotive sector for companies to set up their own internal academies and training centres, which is the case with most OEMs. This shows the importance given to skills development by the established/formal private sector in Turkey. But more cost-effective and innovative solutions are needed to address the needs of smaller, less formal companies, probably through utilising the public-private partnership approach.

ANNEXES

Annex 1. Key stakeholders consulted

The following table lists all the stakeholders that were consulted during the project, either in different workshops and focus group discussions or in bilateral online interviews with the Turkish representatives.

No	Organisation (alphabetical order)
1.	AES Acar Industrial Systems A.Ş.
2.	AKT Centre of Applied Research A.Ş.
3.	AKTAŞ Holding
4.	Anadolu University
5.	Autoliv Turkey
6.	BİRİNCİ A.Ş.
7.	BOSCH A.Ş.
8.	CAVO A.Ş.
9.	CADEM A.Ş.
10.	Cevdet İnci Training Foundation
11.	Coşkunöz Education Foundation
12.	ENGINSOFT TURKEY A.Ş.
13.	Entek Otomasyon Ürünleri A.Ş.
14.	European Bank for Reconstruction and Development (EBRD) Turkey office
15.	ERMETAL Automotive A.Ş.
16.	EU Delegation to Turkey (Education, Training, Employment sections)
17.	FARPLAS A.Ş.
18.	Gazi University
19.	HONDA A.Ş.
20.	İnci GS Yuasa A.Ş.
21.	Industrial Automation Manufacturers' Association (ENOSAD)
22.	International Labour Organisation, Turkey Office
23.	IŞKUR (Turkish Employment Agency)
24.	IT&L
25.	KORDSA A.Ş.
26.	Maxion Wheels A.Ş.
27.	Maysan Mando A.Ş.
28.	MAXIM INCI A.Ş.
29.	Middle East Technical University (METU)
30.	Otokar A.Ş.

No	Organisation (alphabetical order)
31.	Robo Otomasyon Engineering Elec. Mac. Ind. and Trade Inc.
32.	Standard Profil A.Ş.
33.	Teknorot – Steering & Suspension Parts A.Ş.
34.	TEMSA A.Ş.
35.	Tofas – Turkish Automotive Factory A.Ş.
36.	Turkish Association of Authorised Automotive Dealers (Otomotiv Yetkili Satıcıları Derneği – OYDER)
37.	Turkish Economic Policy Research Foundation (TEPAV)
38.	Turkish Automotive Manufacturers Association (Otomotiv Sanayii Derneği – OSD)
39.	Turkish Automotive Suppliers' Association (TAYSAD)
40.	Turkish Employers' Association of Metal Industries (Metal Sanayicileri Sendikası – MESS)
41.	Turkish Composite Industrialists' Association (Kompozit Sanayicileri Derneği)
42.	Turkish Confederation of Employer Associations (TİSK)
43.	Turkish Education Foundation (TEDMEM)
44.	Turkish Industrialists and Business Association (TUSIAD)
45.	Turkish Ministry of Family, Labour and Social Services
46.	Turkish Ministry of National Education (Milli Eğitim Bakanlığı)
47.	Turkish Statistical Institute – Turkstat (Türkiye İstatistik Kurumu – TÜİK)
48.	Turkish Vocational Qualifications Authority (Mesleki Yeterlilik Kurumu)
49.	Turkish Union of Chambers and Commodity Exchanges (Türkiye Odalar ve Borsalar Birliği – TOBB)
50.	TurkTraktor A.Ş.
51.	United Nations Industrial Development Organisation (UNIDO)
52.	Università del Piemonte Orientale
53.	VESTEL Holding
54.	World Bank Turkey office
55.	YEŞILOVA A.Ş.

Annex 2. List of occupational standards and vocational qualifications in the automotive sector developed by the Vocational Qualification Agency

Occupational standards (33) in the automotive sector	VET levels	Occupational competences (27) in the automotive sector
1. Otomotiv Elektrikçisi – Automotive electrician	Level 4	1. Otomotiv Elektrikçisi – Automotive electrician
2. Otomotiv Mekanikçisi – Automotive mechanic	Level 4	2. Otomotiv Mekanikçisi – Automotive mechanic
3. Otomotiv Elektromekanikçisi – Automotive electromechanic	Level 5	3. Otomotiv Elektromekanikçisi – Automotive electromechanic
4. Otomotiv Kaportacısı – Automotive panel beater	Level 3	4. Otomotiv Kaportacısı – Automotive panel beater
5. Otomotiv Kaportacısı – Automotive panel beater	Level 4	5. Otomotiv Kaportacısı – Automotive panel beater
6. Otomotiv Boyacısı – Automotive painter	Level 3	6. Otomotiv Boyacısı – Automotive painter
7. Otomotiv Boyacısı – Automotive painter	Level 4	7. Otomotiv Boyacısı – Automotive painter
8. Otomotiv Montajcısı – Automotive fitter	Level 3	8. Otomotiv Montajcısı – Automotive fitter
9. Otomotiv Montajcısı – Automotive fitter	Level 4	9. Otomotiv Montajcısı – Automotive fitter
10. Otomotiv Gövde Onarımcısı – Automotive carcass repairer	Level 4	10. Otomotiv Gövde Onarımcısı – Automotive carcass repairer
11. Otomotiv Gövde Onarımcısı – Automotive carcass repairer	Level 5	11. Otomotiv Gövde Onarımcısı – Automotive carcass repairer
12. Otomotiv Sac Şekillendirmecisi – Automotive sheet metal moulder	Level 3	12. Otomotiv Sac Şekillendirmecisi – Automotive sheet metal moulder
13. Otomotiv Sac Şekillendirmecisi – Automotive sheet metal moulder	Level 4	13. Otomotiv Sac Şekillendirmecisi – Automotive sheet metal moulder
14. Otomotiv Sac ve Gövde Kaynakçısı – Auto sheet metal and body welder	Level 3	14. Otomotiv Sac ve Gövde Kaynakçısı – Auto sheet metal and body welder
15. Otomotiv Sac ve Gövde Kaynakçısı – Auto sheet metal and body welder	Level 4	15. Otomotiv Sac ve Gövde Kaynakçısı – Auto sheet metal and body welder
16. Otomotiv Ön Düzen ve Balansçısı – Auto front alignment and wheelwright	Level 3	16. Otomotiv Ön Düzen ve Balansçısı – Auto front alignment and wheelwright
17. Otomotiv Kontrol Test ve Ayar İşçisi – Auto control, test and adjustment worker	Level 4	17. Otomotiv Kontrol Test ve Ayar İşçisi – Auto control, test and adjustment workers
18. Otomotiv Prototipçisi – Automotive prototype technician	Level 4	18. Otomotiv Prototipçisi – Automotive prototype technician
19. Otomotiv Prototipçisi – Automotive prototype technician	Level 5	19. Otomotiv Prototipçisi – Automotive prototype technician
20. Endüstriyel Taşımacı – Industrial carrier	Level 3	20. Endüstriyel Taşımacı – Industrial carrier
21. Folyo Uygulamacısı – Foil applicator	Level 4	21. Folyo Uygulamacısı – Foil applicator
22. Motor Test Personeli – Engine tester	Level 4	22. Motor Test Personeli – Engine tester
23. Motor Test Personeli – Engine tester	Level 5	23. Motor Test Personeli – Engine tester
24. Lastik Bakım Onarımcısı – Tyre maintenance and repair personnel	Level 3	24. Lastik Bakım Onarımcısı – Tyre maintenance and repair personnel

Occupational standards (33) in the automotive sector	VET levels	Occupational competences (27) in the automotive sector
25. Ağir Vasita Tecrübe Sürücüsü – Heavy vehicle experienced driver	Level 5	25. Ağir Vasita Tecrübe Sürücüsü – Heavy vehicle experienced driver
26. Motosiklet Bakım Onarımcısı – Motorcycle maintenance and repair personnel	Level 4	26. Motosiklet Bakım Onarımcısı – Motorcycle maintenance and repair personnel
27. Otomotiv Boya Onarımcısı – Automotive paint repairer	Level 4	27. Otomotiv Boya Onarımcısı – Automotive paint repairer
28. Cam Filmi Uygulamacısı – Glass film applier	Level 4	
29. Kalibrasyoncu – Calibrator	Level 4	
30. Kalibrasyoncu – Calibration maker	Level 5	
31. Batarya Elektrikli Araç Bakım/Onarımcısı – Battery-powered electric vehicle maintenance and repair personnel	Level 3	
32. Batarya Elektrikli Araç Bakım/Onarımcısı – Battery-powered electric vehicle maintenance and repair personnel	Level 4	
33. Batarya Elektrikli Araç Bakım/Onarımcısı – Battery-powered electric vehicle maintenance and repair personnel	Level 5	

GLOSSARY

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

Artificial intelligence – AI 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: the recognition of objects or patterns; the classification of entities; simulations and situation modelling; predictions of future behaviours; and the generation of constructs similar to existing ones.

Cognitive bias – is a systematic pattern of deviation from the norm or rationality in judgement. 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' (Cedefop, 2011). While sometimes used as synonyms, the terms **skill** and competence can be distinguished according to their scope. **Skill** typically refers to the use of methods or instruments in a particular setting and in relation to defined tasks. The term competence is broader and typically refers 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, where reusability refers to 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 particular sector or **occupation**. See also **Transversal knowledge**.

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

ESCO – stands for the European multilingual classification of Skills, Competences and Occupations. ESCO works as a dictionary, describing, identifying and classifying professional **occupations**, **skills**, and qualifications relevant to the EU labour market and education and training, in a format that can be understood by electronic systems. It lists over 3 000 occupations and 13 000 skills and competences. For more information, see https://ec.europa.eu/esco/portal/home.

Industry 4.0 – the **Fourth Industrial Revolution** is the ongoing automation of traditional manufacturing and industrial practices, using modern smart technology. The term was first introduced by a team of scientists developing a high-tech strategy for the German government. Large-scale machine-to-machine (M2M) communication and the internet of things are integrated for increased automation, improved communication and self-monitoring, and production of smart machines that can analyse and diagnose issues without the need for human intervention. There are four design principles identified as integral to Industry 4.0: interconnection, information transparency, technical assistance, and decentralised decisions.

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

7 000 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 intended 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 human resources department of a company, and includes all the elements deemed necessary to perform the corresponding **job**. In particular, it includes general tasks, duties and responsibilities, as well as the required **qualifications**, **competences** and **skills** that should be possessed by the post holder.

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

NACE – derived from the French Nomenclature statistique des activités économiques dans la Communauté européenne (Statistical classification of economic activities in the European Community). It is a four-digit classification providing a framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics, supplied by Eurostat. Economic activities are divided into 10 or 11 categories at a high level of aggregation, and into 38 categories at an intermediate aggregation level. NACE Rev. 2 is the latest revised classification, whose implementation began in 2008, for producing comparable statistics at the EU level.

Natural language processing (NLP) – is an interdisciplinary field at the intersection of linguistics, computer science and information engineering. NLP deals with the interactions between computers and human (natural) languages, focusing in particular on 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, and moving 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 1 016 occupational titles, each with standardised and occupation-specific descriptors, covering the entire US 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, jobseekers and human resources professionals, etc. As a programme, it is intended to facilitate the development and maintenance of a skilled workforce, and has been developed under the sponsorship of the US Department of Labour/ Employment and Training Administration. For more information, see www.onetcenter.org/ and www.onetonline.org/.

Occupation – according to ESCO, an occupation is ‘a grouping of jobs involving similar tasks, and which require a similar skill set’. For more information, see ESCO - ESCOpedia - European Commission (europa.eu). 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 a 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' (Cedefop, 2011).

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' (Cedefop, 2011). Skills can be described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (encompassing 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 typically refers to the use of methods or instruments in a particular setting and in relation to defined tasks. **Competence** is broader in scope and typically refers 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 – usually associated with **transversal skills**, soft skills are generally seen as the cornerstone for personal development, and also as germane 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 abilities (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 and articles). The first part of any text-mining process implies the transformation of texts into 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, where reusability refers to 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*, and regarded as forming the cornerstone for individual personal development. 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 provides a basis for more specific technologies (e.g. computerised image analysis).

ABBREVIATIONS AND ACRONYMS

AI	Artificial intelligence
CNC	Computer numerical control machine
ETF	European Training Foundation
EU	European Union
EUR	Euro (currency)
GVC	Global value chain
ICT	Information and communications technology
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
IŞKUR	Turkish Employment Agency
LED	Light-emitting diode
LFS	Labour force survey
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne (Statistical classification of economic activities in the European Community)
NEET	(Young people) Not in education, employment or training
ODD	Automotive Distributors' Association
OEMs	Original equipment manufacturers
O*NET	Occupational Information Network of USA
OSD	Otomotiv Sanayii Derneği (Turkish Automotive Manufacturers Association)
OYDER	Otomotiv Yetkili Satıcıları Derneği (Turkish Association of Authorised Automotive Dealers)
R&D	Research and development
STEM	Science, technology, engineering and mathematics
TAYSAD	Turkish Automotive Suppliers' Association
TOGG	Turkey's Automobile Joint Venture Group
TÜBİTAK	Scientific and Technological Research Council of Turkey
USD	United States dollar (currency)
VET	Vocational education and training
VQA	Vocational Qualification Agency

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