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Skills development of workers for the industry in the European Commission

Supervisors:
Prof. Agostino Villa
Prof. Teresa Taurino

Author:
Oraib Khatib
s236445

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For the ancestors who paved the path before me upon whose shoulders I stand. This is also dedicated to my husband and my family who supported me on this journey.

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Contents

List of Figures

List of Tables

Abstract

The nature of work and the ways it is performed have changed multiple times and throughout human history. However, the pace of change has accelerated significantly, largely due to different Industrial Revolutions.

Skills continue to be the best guarantor of social mobility and opportunity. However, they are not static and need to be updated and fine-tuned throughout working lives. That's why it's important to focus on vocational education and skill development of workers. The most important capital for the world of work ahead is skills that's lead European Social Fund and the European Regional Development Fund to inject over 30 billion EUR to support skills development in the period 2014-2020, while the Erasmus and program support skills development in education and training with nearly 15 billion EUR.

Workers (around the world) in future will need to learn more than science courses, educational institutions need to be improved to deal with the rapidly changes in the work. Education is not just about preparing people for work but also about changing the path of economic development. Decisions about education by both policy makers and individuals will influence how the future will unfold.

There will be several new jobs and tasks in the industry that are not known presently. More engineers will be needed, in fields like robotics, cyber security, software, and hardware integration. The strong presence of technical and practical skills in educational programs will need to be updated and upgraded in order to accommodate contents to the new digital era.

The changing world of work requires a multi-layered policy response, covering the entire life-trajectory, from cradle to retirement. Education, training and the opportunity for retraining throughout one's life need to be the starting point Between 2015 and 2025 opportunities will grow for highly-skilled people (+21%) while stagnating for medium-skill levels and declining for the low skilled (-17%). Depending on the country and occupation, 25-45% of jobs will be subject to automation. This is why up-skilling and re-skilling are indispensable.

The European Commission wants to help all industrial sectors exploit new technologies and manage a transition to a smart, Industry 4.0 industrial system. Industry 4.0 may help to reverse the past decline in industrialization and increase total value added from manufacturing to a targeted 20% of all value added by 2020.

To foster cross-functional knowledge and communication, universities should increase the number of interdisciplinary study programs that integrate IT and engineering, building on current programs in business informatics and business engineering , and they should focus on building specific capabilities for the new roles and adapting their curricula to meet companies expectations for Industry 4.0 skills.

Industry 4.0, which started off as a brainchild of Germany, is being adopted by countries around the world. Europe accounts for more than a third of global Industry 4.0 investments. In fact, companies that use Industry 4.0 technology can perform 10 times better than their peers by being 10 times more effective, efficient and/or faster. They use, for example, smart devices, connected objects and sensors, cloud and big data analytics. In their journey to adopt Industry 4.0, each country is expected to encounter a number of challenges related to the skill level of their workforce. there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers,

robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate.

Industry 4.0 does not start and end with supply chain or production. Its reach could be much broader, affecting every industry and sector, it can improve business operations and revenue growth, transforming products and the customer experience. That's lead to big differences in the workers of the industrial sector which will need to change their skills development strategy to match with challenges of Industry 4.0.

Therefore, the aim of this thesis is to study and analyze the skills, knowledge, attitudes and competencies of workers for the industry in the European Commission in general and Industry 4.0 in specific. First, we give an overview of the skills worldwide to show that the skills needed for the future are not just about science and technology. Human skills like creativity, leadership, and empathy will be in demand, therefore some directions to emphasise the development of skills will be discussed. After that, we will start focusing on the European commission industrial sector to understand what are the policies they established to decrease the skills gap by introducing e.g., new skills agenda and launching a European Pillar of Social Rights. Secondly, we will see how the Industry 4.0 effects European commission industry, which could boost the productivity and value added of European industries and stimulate economic growth. Moreover, the prioritization technique MuShCo will be discussed for different qualifications and skills. Then Visualized competence model will be analyzed to recognize general gaps at the competence category level and allows an analysis at individual competence level.

In this work, we will focus on three main sectors, Automotive, ICT and Food industrial sectors. Each of these sectors is analyzed and studied to see what are the actions needed by taking into account the knowledge, competencies and attitudes of the workers in order to reduce the skills gap in each sector.

The preferences of enterprises will depend on the type of industrial sector: small and medium enterprise (SME) and large enterprise. We will see in this work that each enterprise has it is own challenges and opportunities. Therefore, it's important to classify the enterprises to study the characteristic for each of them and to see how they reflect on worker skills. Moreover, we will show the benefits of Industry 4.0 on each of the previous main sectors and what are the competencies and skills needed to cope with Industry 4.0. Finally, we will discuss what are the skills policies that can be taken to improve the knowledge and the competencies of the workers.

In particular, the aim of the first chapter is to understand the skills development of workers needed for the industry in European Commission, the chapter has been divided into 3 sections. The first section gives a brief overview of future work skills around the world. In the second section, we will discuss the skills in the European Commission and the main type of skills needed to be updated and upgraded for specific jobs in industry and the effects of lack of skills. Finally, the third section, we will discuss the effect of the world's fourth industrial revolution (industry 4.0) and focus on skills and qualifications that match the changes in manufacturing. Moreover, the recommended actions to be taken into account by companies, education system, academic program, and universities to improve their skills output to succeed in industry 4.0.

The purpose of the second chapter is to concentrate on some sectors and understand the knowledge, competencies, and attitudes of the workers that will be needed in each sector. The three main sectors that will be discussed in this work are the following, (1.Automotive sector 2.ICT sector 3. Food sector). At the end of the chapter, we will summarize the competencies, attitudes, and knowledge for the previous three sectors for future comparison. Moreover, we will introduce a section as a classification of enterprises and compare the characteristic of small, medium and large enterprises. Finally, we will discuss the number of different type of enterprises in specific European cities and the proportion of enterprises in the main sectors.

The goal of the third chapter is to understand the effect of industry 4.0 on the skills and knowledge of the three main sectors employee, we will discuss the benefit of industry 4.0 on each sector. Moreover, we will find out the main skills that will be needed to keep up with this new technology. Finally, the skills policies that can be taken to improve the knowledge and the competencies of the workers.

At the end, chapter four is detected to the conclusion for this work, where we summarized the knowledge, competencies, and attitudes of the workers for different industrial sectors. Moreover, the comparison between small, medium and large enterprises was outlined. Finally, we listed the Skills and competencies that are required for workers in each sector to cope with Industry 4.0 technology.

Chapter 1: Literature Review

Abstract

The aim of this chapter is to understand the skills development of workers needed for the industry in European commission. As the skills and qualifications of the workforce become important to control high qualitative machines and to success the innovative factory. The role of the human effect is increasing significantly in the advanced manufacturing of the future. One of the central questions for this report is whether these skills of employees will serve them to take place in tomorrow's "intelligent" and digitized production factories.

Introduction

The chapter has been divided into 3 sections. The first section gives a brief overview on future work skills around the world to understand the importance of skills development in the work, the skills impact on the economy and comparison between the skills around the countries., In the second section, we will discuss the skills in the European Commission and the main type of skills needed to be updated and upgraded for specific jobs in industry and the effects of lack of skills. Finally, the third section, we will discuss the effect of the world's fourth industrial revolution(industry 4.0) and focus on skills and qualifications that match the changes in manufacturing. Moreover, the recommended actions to be taken into account by companies, education system, academic program, and universities to improve their skills output to succeed in industry 4.0.

1.1 Future work skills around the world

In this section, we will see that workers (around the world) in future will need to learn more than science courses, educational institutions need to be improved to deal with the rapidly changes in the work and also the skill mismatch and their effect on the economic growth. then, we will introduce the Hays-index which discuss the skills occupation around different countries.

According to [35], it's impossible to predict exactly the skills that will be needed even five years from now, so workers and organizations need to be ready to adapt-in each of the worlds we envisage. The skills needed for the future are not just about science and technology. Human skills like creativity, leadership, and empathy will be in demand. Identify the skills you need to concentrate on how to build them and how to use them alongside technology.

Therefore, to be successful in the next decade, individuals will need to demonstrate foresight in navigating a rapidly shifting landscape of organizational forms and skill requirements. They will increasingly be called upon to continually reassess the skills they need, and quickly put together the right resources to develop and update these. Workers in the future will need to be adaptable lifelong learners [15] (see also [12]).

As missioned also in [15], educational institutions at the primary, secondary, and post-secondary levels, are largely the products of technology infrastructure and social circumstances of the past. The landscape has changed, and educational institutions should consider how to adapt quickly in response. Some directions of change might include:

- Placing additional emphasis on developing skills such as critical thinking, insight, and analysis capabilities.
- Integrating new-media literacy into education programs.

- Including experiential learning that gives prominence to soft skills such as the ability to collaborate, work in groups, read social cues, and respond adaptively
- Broadening the learning constituency beyond teens and young adults through to adulthood
- Integrating interdisciplinary training that allows students to develop skills and knowledge in a range of subjects

On the other hand, [26] discuss that rapidly changing skills needs raise the risk of skills mismatch and shortage, both of which have significant economic costs. For individuals, skills mismatch has a negative impact on job satisfaction and wages. For firms, it reduces productivity and increases on-the-job search and turnover, while shortages increase the cost of hiring and hinder the adoption of new technologies. At the macroeconomic level, mismatch increases equilibrium unemployment and reduces GDP growth via misallocation of human capital and/or the reduction in productivity it generates, while skills shortages have equally adverse effects on labor productivity. Furthermore, recent research has shown that countries which are better at meeting the demand for skills also have lower wage inequality (OECD, 2015e). Yet, across many countries with available data, two in five employers claim they have difficulties finding the right people to fill jobs. Further details can be seen e.g., in [67] and [66].

According to [OECD 2017], actual skill levels often differ from what formal education qualifications suggest. For example, tertiary-educated adults in Chile perform better than their less-educated peers, but their scores in literacy and numeracy are well below the OECD average. On the other hand, on average, Japanese and Dutch high school graduates easily outperform university graduates in some other countries.

To examine the trends impact, the Hays Global Skills Index ([31]); which is an annual assessment of the trends impacting skilled labor markets for 33 countries; determining how easy or difficult it is for organizations to find the skilled professionals they need. By averaging across all countries, they found that labor market conditions have eased slightly this year, largely due to declines in overall wage pressures. But within that overall picture, there are significant changes. In Europe and Middle East region, there has been a rise in talent mismatch, but the effect on the overall score has been limited by easing wage pressure in the whole economy. In the Asia Pacific region, rising gaps in the pay between people in high-skill occupations and lower-skill occupations has been counteracted by lower overall wage pressure. And in the Americas, a decline in talent mismatch – due to falling vacancies and long-term unemployment rates – has been outweighed by an increase in wage pressure in high-skill occupations, particularly in Chile.

According to Wilson [66], education is not just about preparing people for work but also about changing the path of economic development. Decisions about education by both policy makers and individuals will influence how the future will unfold. Moreover, Education needs to prepare young people and others for the world of work they are likely to face, but it can also help individuals to play a part in designing and shaping the future, especially through the role of research and development (R&D), innovation and entrepreneurial activities, which can often be seen as a joint product of education (especially at the highest level). Many of the structural changes affecting the economy and labour market are quite robust and likely to result in a continuation of well established trends. This can help to guide thinking about future skills needs. However, there are also many uncertainties. This suggests a need for flexibility and adaptability, and the importance of 'learning to learn'. It also highlights the need for good quality and well informed careers guidance targeted at the individual.

1.2 Skills in the European Commission industry

In this section, as the industry is being developed in European Commission (EC), we will discuss the new technical skills that are needed to deal with many jobs, skills gaps of digital and high-tech technologies and mismatches that European commission try to solve that gap. To do so, the EC introduce new skills agenda aims to bridge the skills gap by equipping people with the necessary skills and up-skilling the existing workforce.

As stated in [14], the industry is the backbone of the European economy. It accounts for 80% of Europe's exports and private innovations and provides high-skilled jobs for citizens. Europe has a global competitive advantage on high value-added products and services. Innovation and competitiveness are therefore at the heart of the Commission's agenda and, as they stand on the brink of a new industrial revolution, they are committed to supporting the transformation of EU industry (see also [43]).

To another extend, the authors in [3] claims that there will be a number of new jobs and tasks in the industry that are not known presently. More engineers will be needed, in particular in fields like robotics, cyber security, software, and hardware integration. The strong presence of technical and practical skills in educational programs will need to be updated and upgraded in order to accommodate contents to the new digital era. Additionally, education and training systems will face the growing challenge of integrating technical, analytical and soft skills training, to promote professionals capable of systemic thinking with an entrepreneurial mindset. Programming and coding skills will be increasingly high in demand in many industrial jobs. The same argument can be found also in [48].

Moreover, the authors in [19] claims that, increasing transversal and basic skills alone will not be sufficient to generate growth and competitiveness, and there is still too much distance between the educational environment and the workplace. Targeted investment in VET (vocational education and training), namely initial and continuous training, is vital for innovation, growth and competitiveness. The value of VET, and notably dual training systems, in facilitating youth employment is now strongly acknowledged. Some European countries already have world-class VET systems (Germany, Austria, Denmark, the Netherlands), with built-in mechanisms to adapt to current and future skills needs so training is more demand-driven. They report fewer problems with skills mismatches and show better employment rates for young people, and in these countries VET education is characterised by dual systems which have a high proportion of work-based learning.

In [20], the changing world of work requires a multi-layered policy response, covering the entire life-trajectory, from cradle to retirement. Education, training and the opportunity for retraining throughout one's life need to be the starting point. The most important capital of the world of work ahead is skills, and yet, many youths, as well as adults across Europe, have considerable basic cognitive and non-cognitive skills deficits even if they hold formal qualifications. Moreover, the European Commission's initiative to launch a European Pillar of Social Rights aims to identify the most transformative trends within work and welfare systems, the changing needs in employment and social policies, and the good practices in meeting these challenges and opportunities. In effect, a dedicated focus of the on-going public consultation process (2016).

Disruptive technology is changing the face of industry on a global scale. To continue to prosper, European enterprises have to be competitive, and the skills of our workforce are key here. That is why they are working to increase the EU talent pool and help people acquire new skills, with a focus on new technologies. Skills are at the heart of industrial policy. Innovation comes from the creativity and skills of individuals. There is a global race for talent and our workforce needs to acquire high-level skills and continuously improve them to boost employability and fuel competitiveness and growth, as reported in [14] (more details can be found in [5] and [24]).

More precisely in [14], the New Skills Agenda adopted in June 2016 aims to ensure that Europeans develop appropriate training and skills. It aims to bridge the skills gap by equipping people with the necessary skills and upskilling the existing workforce. Between 2015 and 2025 opportunities will grow for highly-skilled people (+21%) while stagnating for medium-skill levels and declining for the low skilled (-17%). Depending on the country and occupation, 25-45% of jobs will be subject to automation. This is why upskilling and reskilling are indispensable.

Weng [64], elaborates eight skills in future work which are based on three main changes and are available to different domains of professions. The first change is an increasing technological world for the future. The first two skills in technological era are computational thinking and new-media literacy [15]. Computational thinking and new-media literacy assist in both working effectively and building social network. In the domain of addressing function of brain, skill in relation with cognitive function is strongly emphasize. Sense-making skill can influence people to learn new knowledge, acquire information from phenomena, and make better choices. Sense-making is also working on many realms, such as business [6]. There are three intelligences (social intelligence, emotional intelligence, cultural intelligence) which influence a person's career. Design mindset skill has great power to help people solve problems more creatively and efficiently (Tempore, 2013). Another similar skill is novel and adaptive thinking, which seeks more innovative ideas and solutions. Managing cognitive load skill is also important for modern people who continuously receive a mass of information . Cross-cultural competency is the basic skill for people to live better in the complex and global environment, including the sociality, approach of different ideas and understanding of the spirits from different cultures.

In [27], the author focused on E-skills for the 21st century: foster competitiveness, growth and jobs, the European Commission (EC) laid out a long-term e-skills agenda and proposed a number of corresponding actions in the field of information and communication technology. Progress was reviewed in 2010 and recommended that more needed to be done to address innovation skills and shortages and to implement the European e-skills agenda. 'E-skills for competitiveness and innovation' is used as the overarching term covering three main categories: ICT practitioner skills; ICT user skills; and e-leadership skills. The following recommendations are proposed for ensuring Europe has sufficient e-skills and eleadership skills :(1) launch initiatives in countries lagging behind; (2) scale up efforts through longer term policy commitment; (3) adapt education and training to the digital age; (4) foster ICT professionalism and quality; and (5) build bridges for all students, graduates and workers through high quality information and career-support services to enable students to make informed choices.

1.3 Industry 4.0

1.3.1 Industry 4.0 in the European Commission

In this section, we will introduce the industry 4.0 in European commission and discuss the skills that challenge it. Skills of the graduates are not enough for the market, therefore policy actions needed toward the automation in industry, companies, educational system, the academic community and universities actions with skills needed to succeed with industry 4.0.

From [49], Industry 4.0 rapid transformations in the design, manufacture, operation, and service of manufacturing systems and products. The Industry 4.0 designation signifies that this is the world's fourth industrial revolution, In brief, everything in and around a manufacturing operation (suppliers, the plant, distributors, even the product itself) is digitally connected, providing a highly integrated value chain.So its a new industrial revolution increased flexibility in manufacturing, mass customization, increased speed, better quality and improved productivity (see e.g., [39] and [38]).

According to [55], the rise of new digital industrial technology known as Industry 4.0, sensors, machines, workpieces, and IT systems will be connected along the value chain beyond a single enterprise. These connected systems (also referred to as cyberphysical systems) can interact with one another using standard Internet-based protocols and analyze data to predict failure, configure themselves, and adapt to changes. Industry 4.0 will make it possible to gather and analyze data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs. This in turn will increase manufacturing productivity, shift economics, foster industrial growth, and modify the profile of the workforce—ultimately changing the competitiveness of companies and regions.

In the EU economy, the industrial sector is important and remains a driver of growth and employment. However, the relative contribution of industry to the EU economy is declining. Based on [49], the European economy has lost a third of its industrial base over the past 40 years, by the third quarter of 2014, the value added by manufacturing to the economy in the EU represented only 15.3% of total value added, a decline of 1.2 percentage points since the beginning of 2008.

The author in [28] discussed that companies in the near future will need a skilled workforce to develop and run advanced manufacturing tools and systems and to analyze the data received from machines, consumers, and global resources. This results in a rising need for skilled workers trained in cross-functional areas and with capabilities to manage new processes and information systems.

On the brink of a new industrial revolution, Industry 4.0, which could boost the productivity and value added of European industries and stimulate economic growth. As part of its new Digital Single Market Strategy, the European Commission wants to help all industrial sectors exploit new technologies and manage a transition to a smart, Industry 4.0 industrial system. Industry 4.0 may help to reverse the past decline in industrialization and increase total value added from manufacturing to a targeted 20% of all value added by 2020 (for more details see e.g, [49], [50]).

Two types of skills are likely to be particularly important in the future, as missioned in [49]. First, with the disappearance of routine tasks, growing emphasis will be placed on skills which are more difficult to automate. In particular, there is evidence that the labor market is increasingly rewarding soft skills such as the ability to communicate, work in teams, lead, solve problems and self-organize (e.g. Deming, 2015). Second, the importance of digital skills is increasing. While the demand for ICT specialist skills has been growing fast, the existing evidence does not suggest that major shortages are likely to arise. However, there is much more concern about individuals' ICT generic skills, such as the ability to use communication and information search or office productivity software. Here, existing evidence suggests a significant mismatch between the demand and supply of skills.

Employers need personnel with creativity and decision-making skills as well as technical and ICT expertise, where big data analysts and cybersecurity experts are required. While various initiatives have been undertaken to encourage the acquisition of 'eSkills', young people may not necessarily be interested in the digitalisation of the workplace: in one survey (according to [49]) only 13% of young adults in Germany would definitely consider a career in ICT despite the majority view that the sector offered the best job prospects.

In the context of accessibility to education and training [61] said, it must be pointed out that trade unions have historically been among the most effective delivery agencies for occupational training Italian trade unions, for example, have proposed the establishment of "Competence Centers" or centers of excellence to facilitate the acquisition and delivery of skills; not necessarily within the existing university framework.

1.3.2 skills for Industry 4.0 in European commission

The existing qualifications in Western societies differ greatly in distribution from those needed: Well established educational systems and apprenticeship programs mean that large shares of society have at least medium skills and a relatively small share of people has low skills. And while this might be a good sign for educational systems, it also points to a problem of supply and demand: The potential overproduction of a medium skilled workforce means that there could be a large share of this group struggling to find a job matching their qualifications – they are overqualified for the lower qualification jobs that are also paid less and hence not according to their personal qualifications; while they are not skilled enough to fill the skills shortage in the highest qualification jobs. With industrial work and design losing its appeal to younger generations in Western societies, the problem of a skills gap has arisen in the higher skilled jobs [61], [51].

As Industry 4.0 rolls out and according to [13], there is an increasing need for specialized developers. However, there is a considerable lack of IT training, certification, and experience in the European workforce. Due to the rapid technological innovations in IT, the skills of IT graduates do not match the needs of the market. The European Commission expects that the shortage of IT-skilled staff could reach 825,000 by 2020. Moreover, labor market demand for skills is changing much faster than education patterns, leading to skill mismatches and labor market imbalances. Continuing vocational education and training (VET) and adult learning are therefore important in tackling skill mismatches and obsolescence [59].

Confirming to [59], the immediate consequence of such changes is the need for specific skills, that are currently largely unavailable. This gap needs to be urgently addressed both by policy actions and by the industry. According to current data and estimates for the future, there is (and there will be) a substantial skill gap. Last year, the European Commission proposed to establish a framework to coordinate national and EU level initiatives and relevant policy actions including, among others, regulatory conditions and adaptation of the workforce, involving up-skilling. Advances in automation, robotics, and smart systems are increasingly transforming the nature of work, not only for repetitive tasks but also for sophisticated tasks in administrative, legal or supervisory functions. Figure 1.1 shows the data worker's skills gap in selected countries.

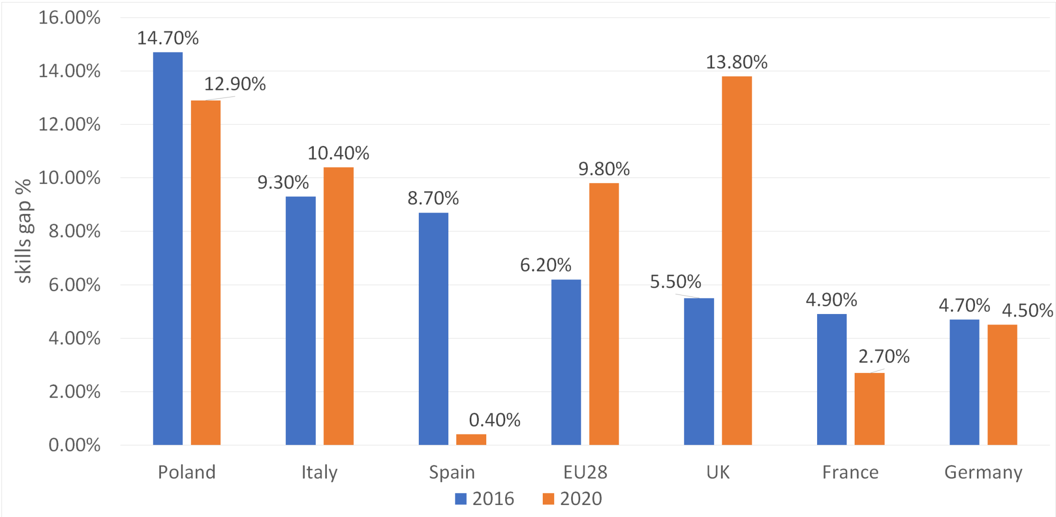

Figure 1.1 Data worker' skills gap in selected countries (IDC 2016)

Based on Roland Berger [65], important skills that will be required for industry 4.0 can be classified into four main categories:

- Knowledge about ICT: (Basic Information Technology knowledge, ability to use and interact with computers and smart machines like robots, tablets etc. Understanding machine to machine communication, IT security & data protection).
- Ability to work with data: (Ability to process and analyze data and information obtained from machines, understanding visual data output & making decisions, basic statistical knowledge).
- Technical know-how:(Inter-disciplinary & generic knowledge about technology Specialized knowledge about manufacturing activities and processes in place, Technical know-how of machines to carry out maintenance related activities).
- Personal Skills:(Adaptability & ability to change, decision making, working in the team, communication skills, mindset change for lifelong learning).

In order to prioritize and add more structure to the list of qualifications and skills, the authors in [28] used the prioritization technique "MuShCo" proposed in [Maxwell, 2010]. This method serves to allocate elements to the three priorities "Must", "Should", and "Could" of which "Must" has the highest and "Could" the lowest priority. Applied to the problem at hand, the factors could be further specified into "Must...", Should. . . ", and "Could be included in the skill set of the production worker of the future", as shown in Fig. 1.2.

	Must...	**Should...**	**Could...**
	...be included in the skillset of the skilled labor of the future.		
Technical Q&S	IT knowledge and abilities	Knowledge Management	Computer programming/coding abilities
	Data and information processing and analytics	Interdisciplinary / generic knowledge about technologies and organizations	Specialized knowledge about technologies
	Statistical knowledge	Specialized knowledge of manufacturing activities and processes	Awareness for ergonomics
	Organizational and processual understanding	Awareness for IT security and data protection	Understanding of legal affairs
	Ability to interact with modern interfaces (human-machine / human-robot)		
Personal Q&S	Self- and time management	Trust in new technologies	
	Adaptability and ability to change	Mindset for continuous improvement and lifelong learning	
	Team working abilities		
	Social skills		
	Communication skills		

Figure 1.2 Qualifications and skills in factory of the future.

In [32], distinctiveness of the visualization used for the competences for Industry 4.0 is the aggregation of several radar charts into one composed radar chart, which is shown in Figure 1.3. Therefore, one radar chart got created for every competence category. Those single radar charts further got combined into one aggregated radar chart. This style of visualization enables its viewer to recognize general gaps at the competence category level and further allows an analysis at individual competence level. The scale of the inner radar chart measuring competence categories works on the basis of percentages. By comparing the sum of measured competence level values for a category to the sum of highest possible values, the percentage value gives an average of how qualified an employee is in an entire competence category.

The visualization is based on the concept of radar charts, which are used to display multivariate data in a two dimensional chart. Due to those characteristics they are commonly used for gap analyses and, thus, a convenient instrument to visualize a competence model. In order to visualize competence gaps, radar charts need to comprise the following components: required competencies, a scale, and a required scale value for each competence. In addition to those components, the actual measured value will also be illustrated in the radar chart. That further allows the measurement of the gap between required and measured competence levels. Since the most important competencies for Industry 4.0 were already identified, a scale needs to be defined in the next step. A widely used scale for competence level measurement consists of five levels from nonexistence up to an outstanding peculiarity (one to five) of a competence. The establishment of required competence levels is varying for every job role and therefore needs to be performed when the model is actually in use.

Generally, the developed model enables companies to conduct a competence gap analysis for required competencies in Industry 4.0. The tool is designed to assess individual employees, since the given competencies are too specific to generalize them on an entire workforce. Furthermore, it needs to be considered that the assessment of employees should be conducted by an experienced person to minimize biases and to obtain consistent results. Firstly, the model's competencies need to be weighted accordingly to the department or job profile of the employee to be assessed. As stated earlier, the model shows the most important competencies for Industry 4.0, however, every job profile requires slightly different advancement levels for each competence. Thus, the required scale value for every individual competence needs to be adjusted. Secondly, the assessment of the employee can be initiated. Therefore, an expert should make use of standardized competence assessment, e.g. through surveys or monitoring activities. Results further need to be compiled and transferred into the competence model. Having all requirements defined and all competencies of an employee evaluated, the model will reveal all existing competence gaps. That shows the readiness of an employee for his job in Industry 4.0. Furthermore, it is possible to identify the most critical gaps at first sight. Those are the competencies human resource development needs to focus on. For example, as it is shown in the exemplary visualization of the competence model, social competencies are not sufficiently developed. Analyzing the individual competencies of that category it is obvious that almost none of the competencies reach the required level. Furthermore, the aggregated radar chart shows that leadership and language skills are being the least developed competencies and demand need for action.

Figure 1.3, shows the visualized competence model including an exemplary employee evaluation. Competencies are clustered around their categories and the red area symbolizes the minimum required competence level for each competence. The green area indicates the actual competence level the evaluated employee has. Thus, if the red area is visible at any point that would reveal a competence gap required to get closed with the help of a suitable qualification strategy.

In order to succeed with industry 4.0 by matching the specific job-related skills, some actions (according to [42]) need to be taken:

- Companies will need to retrain their employees, adopt new work and organization models, recruit for Industry 4.0, and engage in strategic workforce planning. Effective training programs for specific job-related skills should include both on-the-job instruction and classroom instruction, It will be essential to offer online competency-based learning programs. Training in a broader set of skills will often be required because many employees will be working on a greater variety of tasks.
- Education systems should seek to provide broader skill sets and job-specific capabilities, close the IT skills gap, and offer new formats for continuing education.

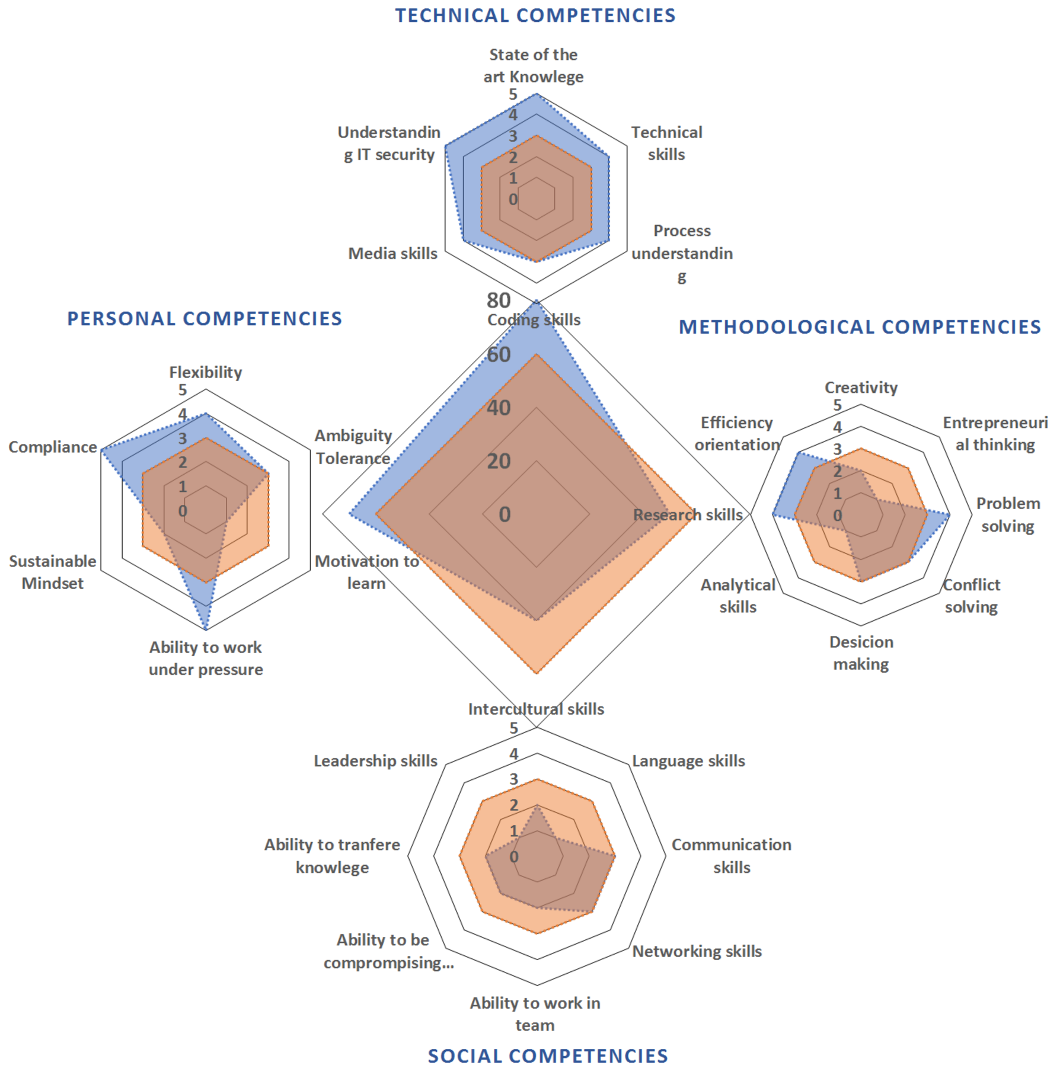

Figure 1.3 Visualized competence model [32]

Lastly, to foster cross-functional knowledge and communication, universities should increase the number of interdisciplinary study programs that integrate IT and engineering, building on current programs in business informatics and business engineering , and they should focus on building specific capabilities for the new roles and adapting their curricula to meet companies' expectations for Industry 4.0 skills.

Chapter 2: Worker Skills

Abstract

In the previous chapter, we try to understand the skills development of workers needed for the industry in European Commission, we made a brief overview on future work skills around the world to understand the importance of skills development in the work. Furthermore, the skills impact on the economy and comparison between the skills around the countries. Also, we discussed the skills in the European Commission and the main type of skills needed to be updated and upgraded for specific jobs in industry and the effects of lack of skills. Moreover, we discussed the effect of the world's fourth industrial revolution (industry 4.0) and focused on skills and qualifications that match the changes in manufacturing. Finally, the recommended actions to be taken into account by companies, education system, academic program, and universities to improve their skills output to succeed in industry 4.0.

The purpose of this chapter is to concentrate on some sectors and understand the knowledge, competencies, and attitudes of the workers that will be needed in each sector. The three main sectors that will be discussed in this report are the following,

- Automotive sector.
- ICT sector.
- Food sector.

At the end of this chapter, we will summarize the competencies, attitudes, and knowledge for the previous three sectors for future comparison. Moreover, we will introduce a section as a classification of enterprises and compare between the characteristic of small, medium and large enterprises. Finally, we will discuss the number of different type of enterprises in specific European cities and the proportion of enterprises in the main sectors.

Introduction

In turbulent environments such as the ICT industry, market changes and company reorganizations require frequent shifts in job function or specialism, and expertise which crystallizes in a single area is likely to jeopardize individual employability [58].

'New careers' concepts suggest that employability and career success depend on continuous learning, being adaptable to new job demands or shifts in expertise, and the ability to acquire skills through lateral rather than upward career moves in varied organizational contexts [33].

As in [40], recent developments in the theory of industrial districts have increasingly emphasized the role of knowledge diffusion in supporting the districts competitive advantages. Moreover, Employee training is considered an important component of a corporation's image and of both its internal and external competitiveness (for more details see e.g., [17]).

Changes of the work conditions and technologies ask to change approach to the main principles of education system, Skills and knowledge must be periodically improved, but attitudes remain as more constant basis for the competences. Attitudes are significant part of employers needs for qualified employees, but their role should be investigated more carefully [36].

The survey results in [36] (Fig. 2.4) show that employers high evaluated not only the professional knowledge and skills of employees, but also their general knowledge and skills, attitudes and motivation. Approximately 42% of employers assessed professional knowledge of employees as very significant factor, 47% – as significant. The general knowledge and skills (languages, computer, driving skills, co-operation ability, ability to plan, control, lead a team) as very significant assessed approximately 26% of employers, as significant – 29%. The attitudes and motivation of employees (initiative, purposefulness, caring for the agenda and organization of work, progress towards development) as very significant assessed approximately 32% of employers, as significant – 44%.

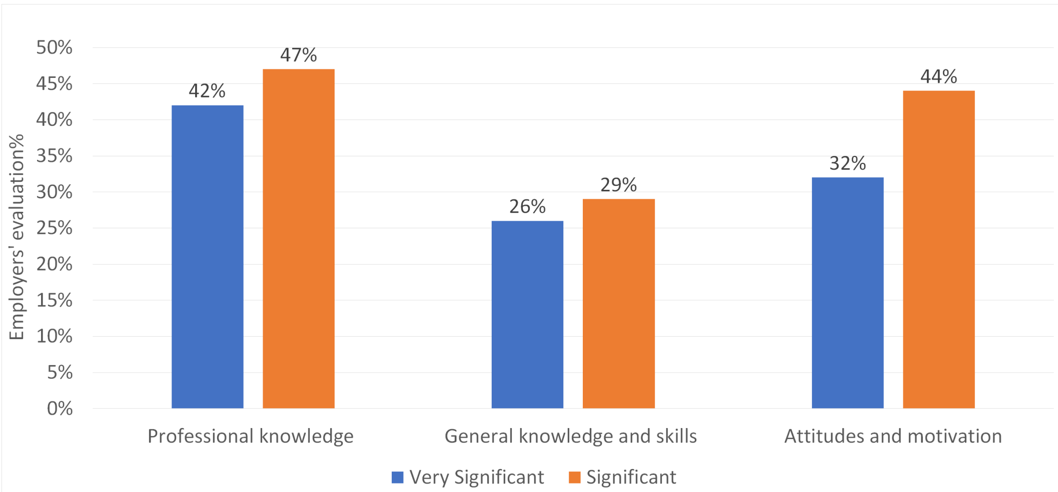

Figure 2.4 Author's calculations based on employers survey conducted in June – October, 2013 ($n = 340$), evaluation scale 1 - 10, where 1 - not significant; 10 - very significant. [36]

Based on *The Future of Work-European Commission* website, refitting education for the demands of the world of work requires novel forms of schooling and teaching with a focus on the application of knowledge. Transversal competences - such as better management of one's own learning, social and interpersonal relations and communication - need to be integrated in all learning methods from pre-school to training schemes for mature workers, as seen in Fig. 2.5.

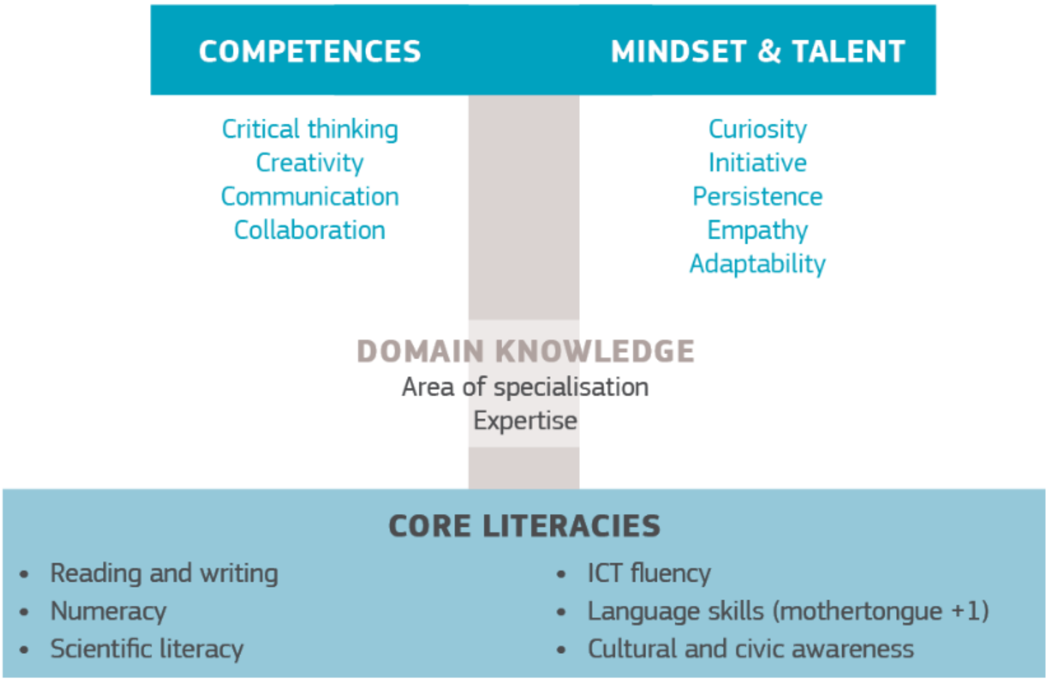

Figure 2.5 Skills and Resilience For a World of Change. Note: This framework is inspired by the T-Skill framework

2.1 Automotive sector

The EU is among the world's biggest producers of motor vehicles and the sector represents the largest private investor in research and development (R&D). To strengthen the competitiveness of the EU automotive industry and preserve its global technological leadership, the European Commission supports global technological harmonization and provides funding for R&D [21].

New requirements and the constant need for innovation are pushing the industry to look for the new skills (e.g. soft skills and flexible engineering) that can be successfully offered by existing future young employees. In this section we will discuss the automotive sector and the worker attitudes, competences and knowledge they need to have.

Firm's ability to continually learn, adapt, and upgrade its capabilities is key to competitive success. The automotive industry offers an interesting opportunity to examine interorganizational learning. Automobiles are developed and manufactured by OEMs (Original equipment manufacturer) and their supplier networks, who produce as much as 70 percent of the value of a vehicle. The key challenge for a knowledge-sharing network is to motivate members to participate and contribute knowledge to the collective good [18]. For example, Toyota's network is effective at knowledge sharing, in part, because a strong network 'identity' has emerged, and the network has established rules (network norms) that support coordination, communication, and learning.

In the interesting report [23], the authors said that, different people learn in different ways, some may learn from methods such as problem-solving exercises, which can encompass a variety of different but interrelated tasks, as can be seen from the Automotive Industrial Partnership project. Others, and particularly adults, have already amassed a variety of attributes on the basis of the life experiences that they already have, and peer-to peer learning is an often-used method, where they can learn in part at least from each other, Others may benefit from an approach, starting with the development of professional and personal skills, which builds up motivation and self-esteem, as in the case of the BMW TalEnt project. The idea is that all stakeholders within the training process can learn a lot from each other if an easy way of sharing and exchanging knowledge, experiences and opinions can be established. Qualifications are used to demonstrate that learners have the knowledge, skills and competence to do a job, or a part of a job. Companies, vocational training institutions and universities are engaged in training engineers, and some of them are offering courses which lead to qualifications in different subjects of importance to the automotive sector.

Therefore, manufacturing companies are faced with the challenge of spreading knowledge, skills and competence around their organisations. This task becomes even more urgent in the automotive industry, when companies notice that qualified technicians and engineers are on the point of retiring, and in many cases valuable company-related skills and experience will be lost. Daimler has been involved in a couple of initiatives to transfer knowledge and skills, firstly based on the knowledge and experience of retired employees, and, secondly based on the mixing of employees with different levels of experience and from different age groups. Retired employees have supported specific departments like production, R&D and IT with their expertise and their skills on a voluntary and temporary basis and pooled their experience so as to contribute to the transfer of knowledge to younger generations.

Based on the article on Apstemps website, there are several traits that are commonly considered when recruiting skilled workers in the automotive industry, such as

- Technology/Automation: Technical employees who know how to implement and leverage the data being generated by the next iteration of automated systems are an asset to any manufacturing organization that wants to lower its cost and control waste.
- Change Leader: Organizations change due to a variety of external and internal forces, managers who know how to effectively communicate change in an organization are essential to maintaining productivity and quality thru an organizational change.
- Problem-Solving Skills: The ability to effectively communicate technical information in the context of solving an issue is a GREAT asset in these large complex manufacturing environments.
- Operational Analysis: Automotive companies need analytical-minded individuals who are able to assess situations through operational statistics as well as first-hand observations as a means of identifying and resolving issues in workflow, operations or productivity.
- Work Ethic: The automotive industry rewards employees who love their work and are in lock step with company production, financial, and safety goals.

- Confidentiality Employers: are also looking for staff members who possess a strong understanding of workplace confidentiality. Because some projects in the automotive industry involve highly sensitive information, proprietary technology or otherwise confidential information, employers want to make sure their employees are able to contain company secrets.

- Industry Familiarity: The automotive industry isn't a field for everyone, Specialized training or certification always looks good on a resume, but it is no substitute for hands-on experience and knowledge.

Employment, Skills and occupational trends in the automotive industry (Annex Report [63]) in Italy shows that, the proportion of engineers more than doubled over the 11 years to 15%, though this was still much lower than in either Germany or France, while in the UK and Spain, the relative number of engineers also rose, though by less than in the other three countries. At the same time, the number of skilled manual workers in the industry in Italy and the UK declined by less than in Germany or France and was still only just under 60% in 2006, and in Spain, it increased slightly to almost 66% of the work force (see Fig. 2.6.

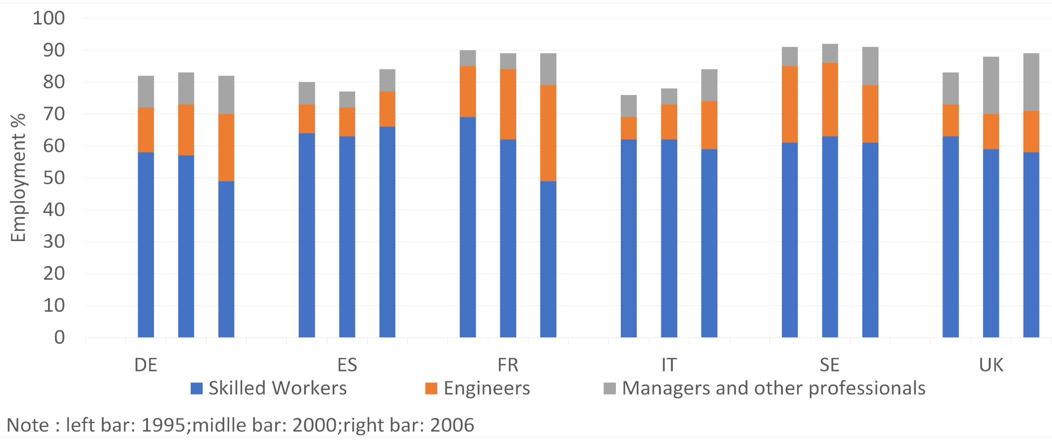

Figure 2.6 Employment in automotive industry by occupation, 1995, 2000, 2006 in EU

Moreover, reflecting the shift in the structure of occupations in the automotive industry, the proportion of the workforce with tertiary – or university – education has tended to rise over the years. Although comparable data on education levels are available only from 2001, they show that over the five years up to 2006, the proportion of workers in the industry with university degrees or the equivalent increased from under 19% to over 22% in the EU, more than in manufacturing as a whole or in the total economy (Figure 37). At the same time, the number employed with only basic schooling declined from almost 29% to 21%, again a bigger reduction than elsewhere in the economy, as shown in Fig. 2.7.

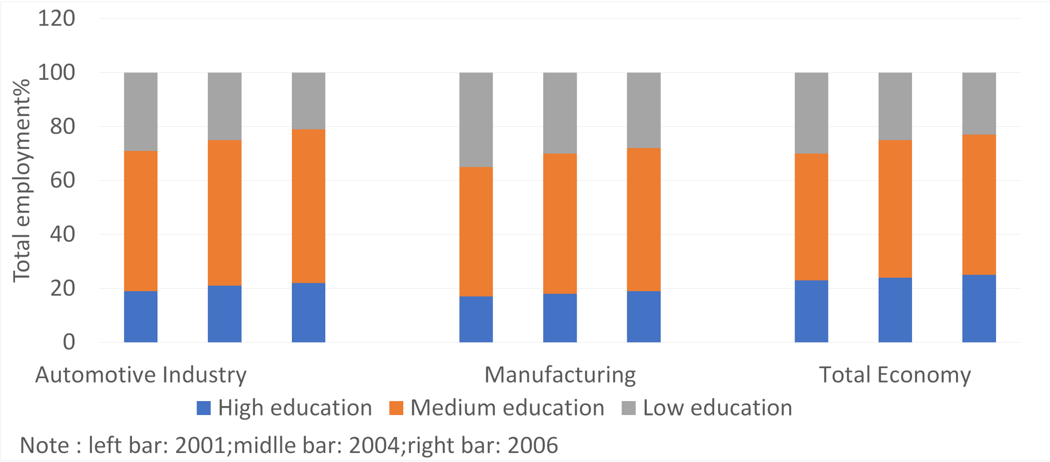

Figure 2.7 Division of employment by education level in automotive industry manufacturing and total economy in the EU.

Some 21% of all those employed in the automotive industry in the EU15 are aged 50 and over, implying that some 1-2% of the work force is likely to retire over the next 7 years or so and will, accordingly need to be replaced if employment were to remain at around its present level, though not necessarily by workers with the same skill profile.

2.2 ICT Sector

The Information and Communication Technologies (ICT) sector value added amounted to EUR 593 billion in 2014. ICT services represented 91% of total ICT value added. ICT services (excluding telecoms) were the main sector and the only one to be expanding [1].

The ICT sector employed 6.3 m people in 2014. The main employer was the ICT services sector (excluding telecommunications) with 4.5 m people in 2014. The share of employment in the ICT sector relative to total employment was 2.8% in Europe in 2014. In this section the attitudes, competences and knowledge for the worker in ICT sector will be discussed. Moreover, employment in the ICT sector represented 2.8% of EU total employment in 2014, remaining stable over the medium-term period. According to the operational definition which enables world comparisons, in comparison with the US (2.7%), the EU (2.5%) fared better than China (1.9%), but all three lagged markedly behind Japan (3.6%) in 2014.

Digital Literacy is increasingly becoming an essential life skill and the inability to access or use ICT has effectively become a barrier to social integration and personal development. Recently, though various actions, institutions of the EU Commission have emphasized in their documents that digital skills are useful tools to improve employability feature of individuals by upgrading the professional required standards or, simply, by allowing access online to job prospects [9].

On the other hand, the rapid shifts in technology, especially in internet and e-commerce, had stimulated demand for highly trained and flexible ICT professionals, flexibility and creativity were the most often cited desirable qualities of ICT professionals across all size bands, but smaller companies (size band 10 – 49) were also predominantly concerned with communication and consultancy skills. Small companies identified a need for both specialization, to stay competitive in their niche market, and greater business awareness, commercial and generalist skills to generate new business. Technical knowledge and project management skills were less often mentioned but still raised by 30% and 22% of the respondents, respectively [57].

The authors in [41] claims that, it is evident that knowledge about telecommunication networks and information processing, followed by programming languages and internet technologies are the main requirements demanded by the sector. Conversely, the most common limitations identified during the study are telecommunication networks, internet technologies and programming languages as shown in Fig. 2.8.

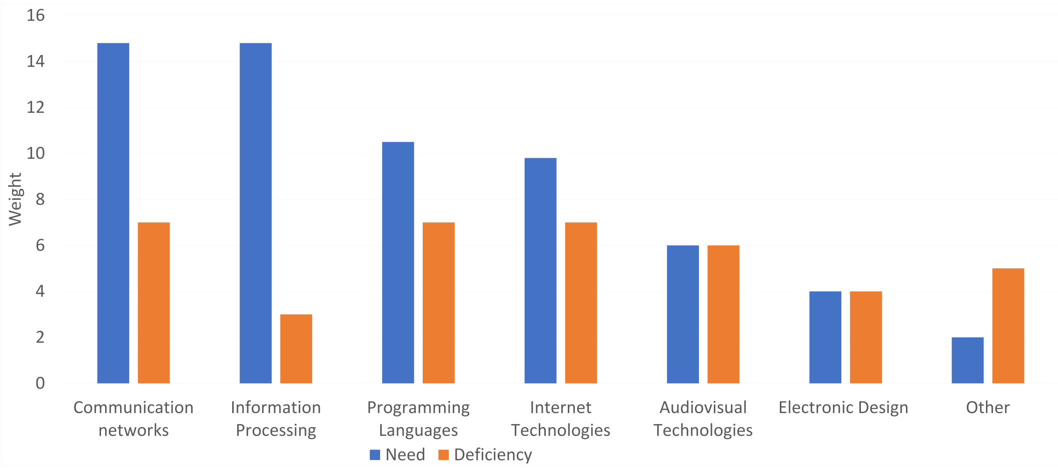

Figure 2.8 Requirements and limitations: technological knowledge [41].

According to Cedefop's European skills and jobs survey (ESJS), the key 5 skills for ICT professionals are advanced ICT skills, problem solving, moderate ICT skills, learning and job-specific skills. These skills could support employees in this occupation to also tackle anticipated future skill challenges.

Moreover, the following eight key competences, proposed by [56], have been established which all people need for fulfillment and personal development: (1) communication in the mother tongue; (2) communication in foreign languages; (3) mathematical competence and basic competences in science and technology; (4) digital competence which can be divided into three levels: IT, information and functional; (5) learning to learn; (6) social and civic competences; (7) sense of initiative and entrepreneurship; (8) cultural awareness and expression.

It is worth noting that, International Labour Organization provided that, the ICT establishments in the private sector has a **skills gaps** of 940 labor units comprising of 34.5% in ICT managers, 8.9% ICT scientists professionals and 7.7% ICT technicians. Liberal professionals and Artisans represented 18.3% and 30.4% of overall skills gaps. The existing employees in the sector also need training in soft (qualitative) skills like leadership, business communication, PR and innovation (see Fig. 2.9).

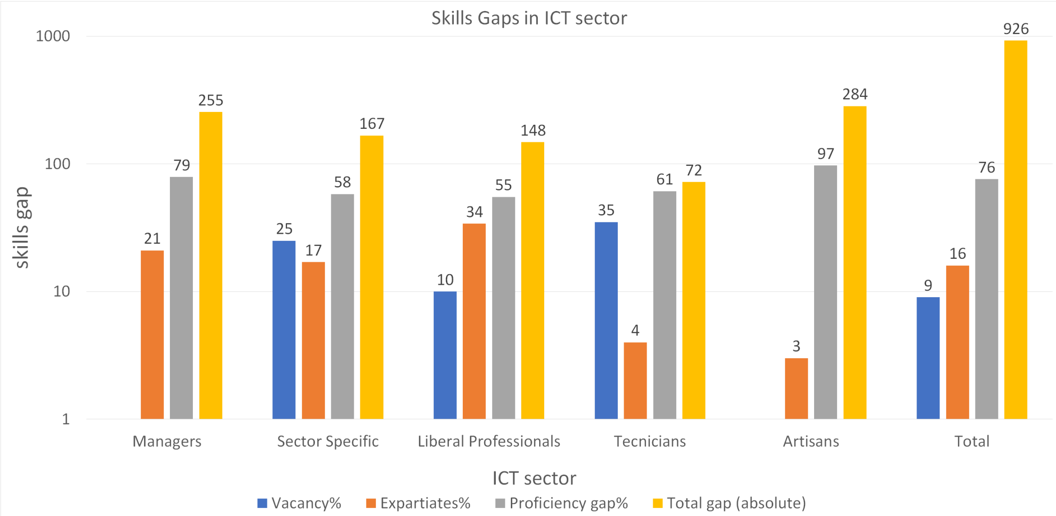

Figure 2.9 Skills gaps in ICT sector. Source: International Labour Organization

According to CaixaBank research, technological change brings with it a change in most jobs and potentially job quality. The emergence of a new technology essentially leads to a new way of producing things with the consequent disappearance of some tasks and the appearance of others. There is also a change in the skills and knowledge required by workers. This transformation in employment affects different workers in different ways. Technology can improve job quality if it complements the work carried out and increases worker productivity. In other cases, technology can be disruptive and wipe out some professions, making effective active employment policies vital. The findings are conclusive in favor of technology: the temporary employment rate is 37% in less technology-intensive sectors, much higher than the rate of 23% found in highly technology-intensive sectors. The difference is particularly large for workers with primary qualifications (see Fig. 2.10).

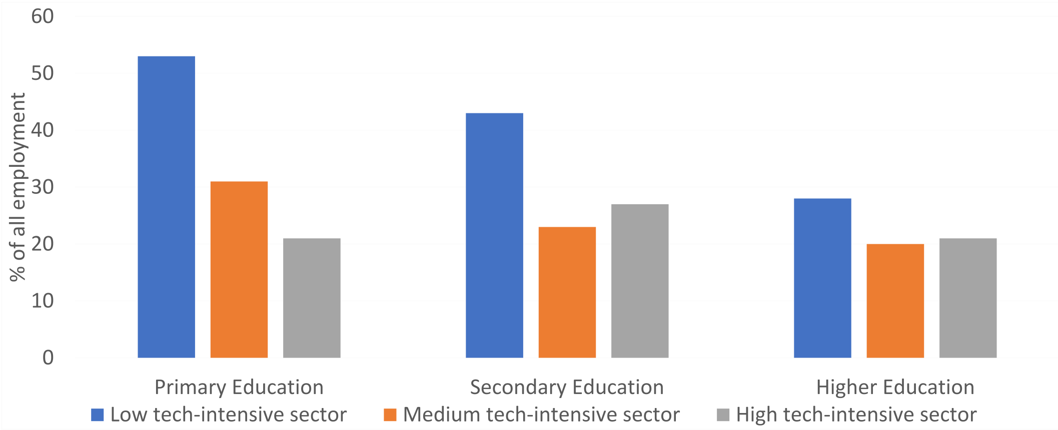

Figure 2.10 Temporary employment rate by ICT capital in the sector and worker's qualifications.

2.3 Food Sector

The food and drink industry is the EU's biggest manufacturing sector in terms of jobs and value added. It's also an asset in trade with non-EU countries. The European Commission is working to improve the competitiveness of the EU food sector and the functioning of the Single Market for Food. It also strives to create new trade opportunities for food and drink products, through various trade negotiations and dialogues with third countries. In this section we will discuss the food sector and the worker attitudes , competences and knowledge they need to have [22].

The table below (Fig. 2.11) provides an overview of the importance of the EU food and drink industry compared to the total manufacturing sector. In 2012, the food and drink industry comprised 290,000 companies, employing 4.5 million people for an annual turnover of €1 062 billion. It is the largest manufacturing sector in the EU, representing 15% of total manufacturing turnover, 14% of the total number of companies and 15% of total employment.

Greater food safety requires enhancing local scientific and technical skills and the development of efficient tools and training programmes, Training assessments analysed the knowledge acquired by employees through pre- and post-training evaluation methods. Attitudinal and behavioural changes at

manufacturing industry

EU28	Food and Drink industry		Manufacturing industry	
	2012	Growth 2008 – 2012 (%)	2012	Growth 2008 – 2012 (%)
Turnover (bn€)	1,062	6.9%	7,080	-0.8%
Number of enterprises	288,655	7.4%	2,130,000	1.4%
Number of employees (1,000)	4,530	0.0%	30,000	-8.6%

Source: Eurostat Structural Business Statistics (SBS).

Figure 2.11 Overview of the EU food and drink industry compared to the total manufacturing sector.

the workplace were also observed, after training was provided, the studies found that there was a considerable enhancement in knowledge acquisition by employees, as well as positive attitudinal and behavioural changes. Some studies indicated that there were significant differences in the level of microorganisms found in food preparation and handling, in employee knowledge levels and in their use of body ornaments [44].

Moreover in [53], positive attitude formation leads to positive behaviour. On the contrary, superficial knowledge leads to misconception and development of negative attitudes. As a result, it increases harmful practice. In fact, many vendors have sufficient knowledge to ensure hygienic handling of food, such as the knowledge of the dangers of contamination, storage, preparation of food.

The authors in [7] claims that, education of staff should be directed to the relevant technological and management knowledge for the specific quality control points they are responsible for. The adoption of basic statistical techniques is necessary for organizing and data processing because they are used for analysis and argumentation. Moreover, the food industry contributes nutrition education by offering products that meet the current needs of consumers and by informing them about the ingredients and nutritional characteristics of the product. Bearing in mind the important role that the industry has to supply the population, education is seen as one of the social responsibility of the food industry.

Highly qualified employees, such as dietary technicians, technologists, engineers, engineers for the research and development, marketing experts, are more than necessary, especially when we take into account the necessity and obligation of a company engaged in food production to meet the complex criteria related to quality issues , food safety, environmental protection, social responsibility, customer expectations and demand for healthier food products, increasing competitiveness, requires international organizations and regulatory bodies.

Employment and Training Administration proposes an interesting Food and Beverage Service Competency Model. The national competency model for the food and beverage service industry sets a consistent standard for educators and employers and provides employees, prospective employees, and influencers a clear understanding of how to best enter, advance, and succeed in the industry, as shown in Fig. 2.12.

1-Personal Effectiveness Competencies	2-Academic Competencies
Interpersonal Skills	Communication
Integrity	Reading
Professionalism	Critical and Analytic Thinking
Dependability and Reliability	Science Principles
Adaptability and Flexibility	Basic Computer Skills
Ability and Willingness to Learn	Writing
Motivation	Mathematics
3-Workplace Competencies	4-Industry-Wide Technical Competencies
Problem Solving and Decision Making	Service Quality
Customer Focus	Product Quality and Cost Control
Teamwork	Food Safety and Sanitation
Working With Tools and Technology	Marketing and Branding
Health and Safety	Restaurant And Food Service Industry Principles And Concepts
Career Skills	
5-Industry-Sector Technical Competencies	6-Occupation Specific Requirements: Management Competencies
Culinary Arts	Safety And Regulations
Service Culture	Leadership Skills
Beverage Service	Monitoring And Controlling Resources
	Purchasing
	Manage Daily Operations
	Financial Management
	Marketing
	Staffing

Figure 2.12 Food and Beverage Service Competency Model.

As well as, in [68], knowledge, attitudes and practices of food handlers are important for identifying how efficient training in food safety is allowing prioritize actions in planning training, as shown in Fig. 2.13. These evaluations are important to detect that the assessment be applied before and after training.

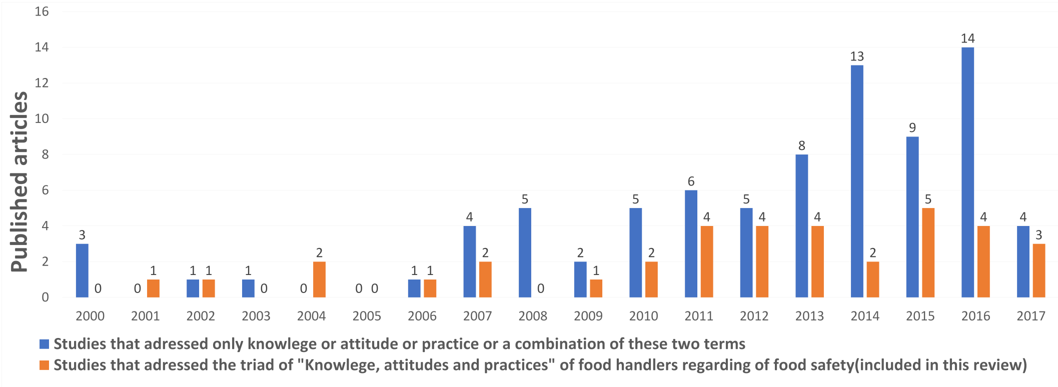

Figure 2.13 Overview of publication´s number on knowledge, attitudes and practices of food handlers in food safety, published each year between the years 2000 and February 2017.

An interesting percentage distribution of level of knowledge, attitude and practice of food safety in Nothern Kuching City Sarawak is discussed in [53]. It worth nothing that Nothern Kuching City Sarawak is not EU country, however the result has an interesting indications that could be helpful in this report. In Fig. 2.14, all the individual items of knowledge, attitude and practice variables were analyzed using factor analysis and ranked into three categories namely poor, average and good by Blom's formula. Analysis revealed that all the respondents had consistently poor knowledge (20.5%), attitude (17.2%) and practice (16.9%). However, average attitude (62.9%) and food safety practice (71.5%) was high compared to knowledge (41.6%), but the good attitude (19.1%) and practice (10.8%) were low compared to knowledge (36.8%).

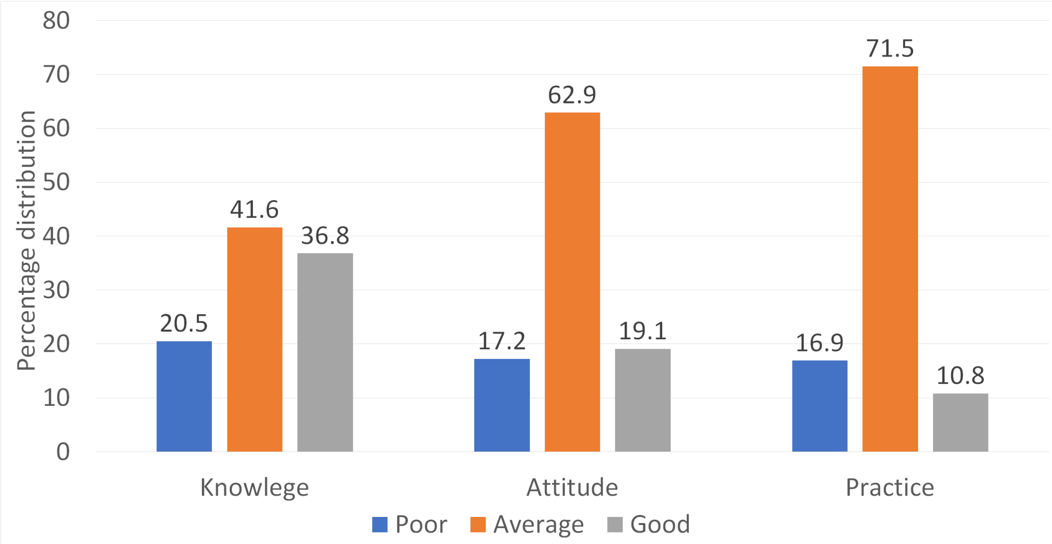

Figure 2.14 Percentage distribution of level of knowledge, attitude and practice of food safety.

2.4 Enterprise Classifications

By dividing the companies into three groups – small, medium-sized, and large enterprises, the authors in [37] claims that, the findings suggest that small companies experience more knowledge constraints than their medium-sized and large counterparts, while large enterprises are challenged by the changes imposed by the ERP system adoption. Further, medium-sized, and large enterprises seem to be more outward-oriented in ERP system adoption than small enterprises. It is also concluded that business development, as opposed to mere efficiency improvement, while being the most prevalent objective for ERP adoption in all the company groups, is considered especially important by medium-sized enterprises.

Compared to their larger counterparts, smaller enterprises typically exhibit limited access to resources such as time, skills, and money (Welsh and White, 1981), Further, due to a lack of slack resources, smaller enterprises in general are more vulnerable to the environmental effects and misjudgments (d'Amboise and Muldowney, 1988; Welsh and White, 1981). Limited resources also force smaller enterprises to allocate more time to adjusting to, rather than predicting and controlling, the turbulence they are faced with (d'Amboise and Muldowney, 1988).

Also, the management skills needed for information systems planning and organization have been found to be limited in SMEs (small and Medium enterprises) (Bilili and Raymond, 1993; Levy and Powell, 1998; Mitev and Marsh, 1998). In addition to hindering IT/IS planning (Proudlock et al., 1998), the resource constraints faced by SMEs may hinder their ability to maintain technology up to date, while at the same time forcing them to consider their investments in IT as something that should last for a long time (Levy and Powell, 1998).

The constraints may also force SMEs to assume an incremental approach to IT investments, which, in turn, may result in isolated and incompatible systems (Hasmi and Cuddy, 1990), as well as decreased flexibility (Levy and Powell, 1998). As a result, there is an evident discrepancy between the management methods and skills employed by SMEs, and the systematization and the resources required by IT/IS planning and implementation (Bilili and Raymond, 1993), although previous research has suggested that adoption, implementation, and management of IT/IS in SMEs is problematic, the differences between different sized companies in ERP adoption have remained largely unexplored. In some aspects, however, the adoption of an ERP system might actually be easier for smaller companies, which have less established structures and policies and thus more flexibility (Levy and Powell, 1998).

SMEs, in general, have been found to be characterized more by a focus on day-to-day survival than long-range strategic thinking (Levy and Powell, 1998; Proudlock et al., 1998). This is partly due to resource poverty and vulnerability to external effects typically exhibited by the smaller companies. The focus on survival rather than on strong long-term strategies has been found to lead to an emphasis on efficiency, cost reduction, and automation in IT/IS investments in SMEs (Ballantine et al., 1998). large enterprises have been found to place more value on improved innovation capabilities and business process improvement than small and medium-sized companies (Bernroider and Koch, 2001; Buonanno et al., 2005).

The companies are divided into small, medium-sized, and large enterprises. SMEs are defined here as enterprises with fewer than 250 employees. Moreover, no commonly agreed definition of a small enterprise, we choose to define small enterprises as companies with less than 50 employees. The same definition of small enterprises has been previously applied by, for example, Chau (1994, 1995). Consequently, medium-sized enterprises are defined as companies with more than 50 but less than 250 employees. Large companies, then, are those companies that do not meet the definition of SMEs and have more than 250 employees. The small companies also reported a significantly lower adequacy of information for decision-making in ERP selection than either medium-sized or large companies.

Now, according to [47] enterprise knowledge management entails formally managing knowledge resources in order to facilitate access and reuse of knowledge, typically by using advanced information technology. KM is formal in that knowledge is classified and categorized according to a prespecified but evolving ontology into structured and semi structured data and knowledge bases. The overriding purpose of enterprise KM is to make knowledge accessible and reusable to the enterprise.

Different kinds of technological data are continuously generated in manufacturing enterprises, concerning the production of specific products. Especially in small enterprises. To address the problem of the lack of communication between different actors involved during the product lifecycle Gunendran and Young (2010) explored a methodology to improve the communication between designers and manufacturing engineers [10].

In the manufacturing domain, the development of products requires a wide range of information and enterprises should effectively be able to store and integrate data to represent the manufacturing processes. In managing Small and Medium sized Enterprises (SMEs), a typical obstacle that has to be approached is how to efficiently manage the technological data to derive knowledge from them [62].

The need of a management system to support the solution of technological problem (e.g., modifying a product, applying a new work tooling, changing an operation inside a work sequence), according to [10], is deeply felt by SME managers. They may have very good experience on manufacturing processes, but they are less skilled in organizing information and thus they must be supported for innovation.

In a manufacturing SME, production operations are executed by either manufacturing or assembling units (also called resources). Products of different types are processed, according to given production plans, under the control of personnel, each one with a properly assigned role. The production resources, allocated in the department, together with the logistic network for their loading/unloading and the required roles, define the SME production system (Kalpakjian and Schmid 2013). According to this definition, a representation of a production system implies to have at disposal the information about the resources, the roles and the manufacturing operations available in the enterprise, and the relations existing among them, Furthermore, each product processed by the company must have a detailed representation, in terms of components and production operations needed. This knowledge is usually represented by the bill of material (BOM) and the working sequence.

Researches indicate that the percentage of knowledge available in a structured and reusable format is very low in companies (less than 5%) and the rest is either unstructured or resides in people minds [11].

According to this definition and to the works of Baxter et al. (2009), Goossenaerts et al. (1998), Ameri and Dutta (2005), it follows that a detailed representation of a production system implies to have at disposal technological data on each resource and the operations to be executed there: this defines the process knowledge. On the other hand, each product processed by the system must have a proper detailed representation, in terms of components and production operations to be applied: this define the product knowledge base [4] ((see also e.g, [54],[8] and [29])).

Automotive CEOs focused on differentiating enterprise models ([2]), three-quarters of those pursuing enterprise model innovations told us they intend to specialize in areas that are truly differentiating. One example of an automotive company that has successfully followed this strategy is mirror maker Gentex. It specializes in high value mirrors with high-tech safety and convenience features. This single-minded focus has helped the company achieve superior financial performance in what most would consider a commodity business.

The role of Micro, Small and Medium-sized Enterprises (MSMEs) in supporting economic growth and job creation is well established. Recently, tech MSMEs and startups have been thrust into focus, with governments seeking to enable domestic tech ecosystems and encourage home-grown digital products and services, including online marketplaces which make it easier for companies to transact with customers locally and abroad. ICT services have enabled the broader MSME population in general but have also created unique opportunities for new entrants to introduce products and services which are transforming traditional industries [45].

As noticed in the article written by Michael Hennigan in Feb. 4, 2015, the size of business firms is often linked with their propensity to export and the business structure, in Germany as illustrated in the chart below shows a high percentage of medium and large size firms compared with the EU28 average. The country has a significant presence in capital intensive industries such as motor vehicles, chemicals and machine tools.

Moreover, Most Italian SMEs are active in wholesale and retail trade, which account for 86% of all SME employees according to the European Commission. Compared to the EU average, they are also more prevalent in manufacturing, in particular traditional sectors such as food and beverage, clothing, textiles, as well as the manufacturing of metal products, machinery and equipment. This shows how important small businesses are for the Italian economy, but also suggests the persistence of significant bottlenecks and limits to growth for SMEs (see Fig. 2.15).

	Number of enterprices			Number of employees		
	Germany		EU-28	Germany		EU-28
	Number	**Proportion**	**Proportion**	**Number**	**Proportion**	**Proportion**
Micro	1809029	81.80%	92.40%	4974919	18.70%	29.10%
Small	336111	15.20%	6.40%	6300111	23.60%	20.60%
Medium-sized	56004	2.50%	1.00%	5445644	20.40%	17.20%
SMEs	2201144	99.50%	99.80%	16720674	62.70%	66.90%
Large	10608	0.50%	0.20%	9941295	37.30%	33.10%
Total	2211752	100.00%	100.00%	26661969	100.00%	100.00%
	Number of enterprices			**Number of employees**		
	Spain		EU-28	Spain		EU-28
	Number	**Proportion**	**Proportion**	**Number**	**Proportion**	**Proportion**
Micro	2129549	94.40%	92.40%	4206346	40.40%	29.10%
Small	109212	4.80%	6.40%	2041958	19.60%	20.60%
Medium-sized	14016	0.60%	1.00%	1384445	13.30%	17.20%
SMEs	2252777	99.90%	99.80%	7632749	73.40%	66.90%
Large	2669	0.10%	0.20%	2771230	26.60%	33.10%
Total	2255446	100.00%	100.00%	10403979	100.00%	100.00%
	Number of enterprices			**Number of employees**		
	Italy		EU-28	Italy		EU-28
	Number	**Proportion**	**Proportion**	**Number**	**Proportion**	**Proportion**
Micro	3527452	94.80%	92.40%	6629987	45.80%	29.10%
Small	171658	4.60%	6.40%	3049375	21.10%	20.60%
Medium-sized	19126	0.50%	1.00%	1837003	12.70%	17.20%
SMEs	3718236	99.90%	99.80%	11516365	79.60%	66.90%
Large	3139	0.10%	0.20%	2960003	20.40%	33.10%
Total	3721375	100.00%	100.00%	14476368	100.00%	100.00%

Figure 2.15 Number of Enterprises in EU.

In addition , based on Destatis website, in Germany: the economic importance of SMEs varies between the individual economic sectors. SMEs are of particular importance in construction and in the hotel and restaurant industry. In the reference year 2015, they generated 85% of turnover and their share in the persons employed was about 92%. In real estate activities and in some branches of services, SMEs are predominant, too. Contrary, the turnover of large enterprises in the total of enterprises is significant in manufacturing and in transport, storage and communication. The economic sector with the smallest proportion of small and medium-sized enterprises is that of energy supply, where SMEs accounted 3% of turnover and 14% of the persons employed in the reference year, as shown in Fig. 2.16.

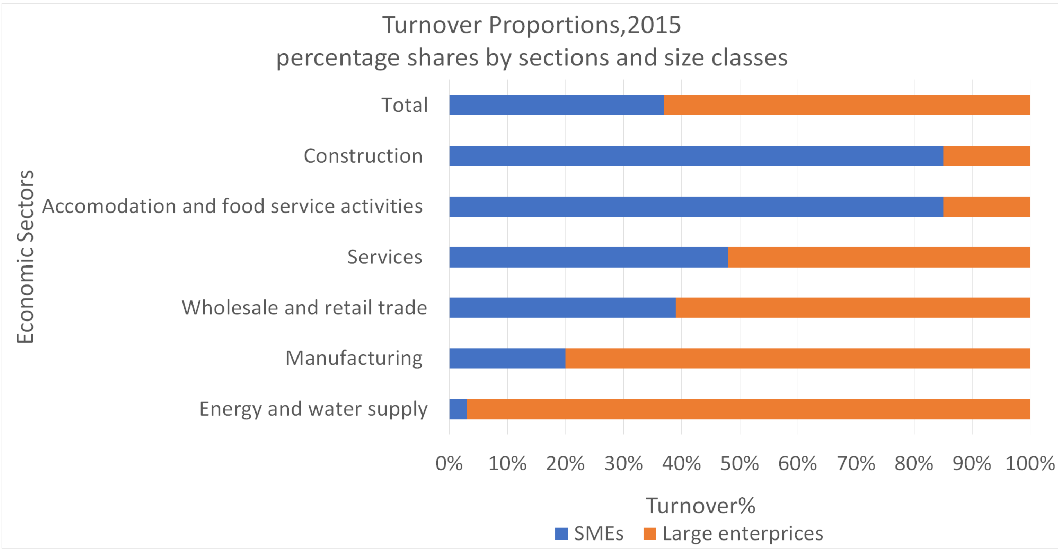

Figure 2.16 Proportion of enterprises in Germany 2015.

Chapter 3: The effect of industry 4.0 on the worker skills

Abstract

In the previous chapter we focused on Automotive, ICT and Food sectors to understand the knowledge, competencies, and attitudes of the workers that will be needed in each sector. Furthermore, we introduced a classification of enterprises and compared between the characteristic of small, medium and large enterprises. Finally, we discussed the number of different type of enterprises in specific European cities and the proportion of enterprises in the main sectors.

The purpose of this chapter is to understand the effect of industry 4.0 on the skills and knowledge of the three main sectors employee. We will discuss the benefit of industry 4.0 on each sector and we will find out the main skills that will be needed to keep up with this technology. Finally, the skills policies that can be taken to improve the knowledge and the competencies of the workers will be discussed.

Introduction

The rise of new digital industrial technology known as Industry 4.0, a transformation that is powered by nine foundational technology advances. The connected systems (also referred to as cyberphysical systems) can interact with one another using standard Internet-based protocols and analyse data to predict failure, configure themselves, and adapt to changes. Industry 4.0 will transform production: isolated, optimized cells will come together as a fully integrated, automated, and optimized production flow.

Based on [55], the Nine Technologies that transforming production in Industry 4.0 are:

1. **Big Data and Analytics:** mass data analysis to support real-time decision making.
2. **Autonomous Robots:** interaction with humans and improvement of performance.
3. **Simulation:** reproduction of the real world in a virtual model to perform tests and optimise machine programming.
4. **Internet of Things:** based on the connection of machines and systems in the productive space and a fluid exchange of information with the outside world.
5. **Horizontal and vertical integration of systems:** manufacturers, suppliers and clients are closely connected via computer systems, providing truly automated value chains.
6. **Cybersecurity:** to protect critical industrial systems and production lines against hacking, industrial copyright, personal data and privacy.
7. **The cloud:** for task enabling and to make more computer services work in production.
8. **Additive manufacturing:** 3D printing reduces raw materials, stocks and transport distances.
9. **Augmented reality:** this will give workers real-time information in order to improve decision making and work processes.

In the short term, the trend toward greater automation will displace some of the often low-skilled laborers who perform simple, repetitive tasks. At the same time, the growing use of software, connectivity, and analytics will increase the demand for employees with competencies in software development and IT technologies [55]. As a result of that its important to identify the knowledge needed for employees in each sector.

3.1 Automotive sector and Industry 4.0

Most automotive manufacturers and suppliers have willingly started down the road to Industry 4.0 which leads devices connect to each other and to human interfaces, providing real-time data from myriad sensors, also Use cases of industry 4.0 such as 3D printing, robotics, and collaborative IT can aid OEMs to enhance product design and transform traditional production and supply chain inefficiencies. 4.0 will effect deeply automotive sector by three key enablers, namely Cloud computing, cyber security and Big Data analytics.

3.1.1 Benefits of Industry 4.0 for the Automotive Sector

Industry 4.0 is a framework that will be able to bring unique benefits for automotive sector. Those benefits can be summarized as follows:

1. Agile supply chain: Industry 4.0 gives OEMs and suppliers the agility to quickly adapt manufacturing specifications in response to changing standards.

2. Self-monitoring capabilities: Industry 4.0-enabled plants to have robust monitoring systems to identify potential maintenance issues before they cause downtime. the same technology can be used in cars themselves to decrease unexpected breakdowns

3. Capacity for customization: evolving toward Industry 4.0 would give auto manufacturers the ability not only customize individual vehicles, but also shorten the delivery time for those vehicles

4. Network flexibility: Industry 4.0 connect all automotive manufacturers which have different locations all over the world via Internet.

Therefor, Industry 4.0 creates many new opportunities for automotive companies, but at the same time several challenges arising from the ongoing automation and digitization. Consequently, the qualifications and skills of the skilled labour, which are required to fulfill the tasks occurring in a factory of the future, will differ as well.

3.1.2 Skills and Competencies of workers in Automotive sector for Industry 4.0.

The evolution toward Industry 4.0 also presents some key challenges that automotive manufacturers must overcome. Therefore, workers will require to have new skills and competencies to deal with the industry 4.0. Such of these skill can by summarized as follows,

1. Creativity: sometimes program algorithm and robots don't work as workers when there is malfunction in the design of vehicle. Therefore, creative and critical thinking are important to give the ability to make connections between unrelated phenomena, and to generate solution.
2. Quality core tools skills: it's important to control and monitor the manufacturing of automotive parts especially with advanced technology and machines, Moreover, they are divided into the following parts :
    - Advanced Product Quality Planning (APQP),
    - Failure Mode and Effects Analysis (FMEA),
    - Measurement Systems Analysis (MSA),
    - Statistical Process Control (SPC),
    - Product Part Approval Process (PPAP).
3. Problem and Conflict solving: when the machines or robotics in automotive supply chain stop working, the workers need to be involved to solve the problem.

4. Decision making: As industry 4.0 is opening the loop, automotive designs will be various, so workers will need skills of gathering information to identify a decision with different choices and assessing alternative resolutions.

5. Specialist skills such as programming, knowledge about robotics which are used for assembly, welding and painting application in automotive sector, they are required due to technological advancements of industry 4.0.

6. Analytical skills: with innovative automotive sector, big data will be used as one of the technologies of industry 4.0 the ability to visualize, gather information, analyse, solve complex problems, and make decisions is required.

7. Leadership development skills: To make good integration between clients and suppliers of automotive industry, people management and communication skills are important.

An interesting questionnaire in 2017 [30] was established by experts in automotive sector to understand the importance of a selected managerial competencies in industry 4.0. Arithmetic mean and standard deviation were founded for each competence as shown in Table 3.1. Where, **Arithmetic Mean** was established based on dispersion or variability for each competence, each value of the **Arithmetic Mean** give us how much important this competence for industry 4.0; e.g., decision making is the most important competence as it take the highest arithmetic means. On the other hand, the **Standard Deviation**, was calculated to tell us how much the measurement is close or spread out from the average, by that we noticed that research skills took the highest standard deviation and therefore gives a less importance by the experts.

As we can see in Table 3.1, experts (practitioners) give a very high value to competencies related to decision-making, this is because the ability to choose the right decisions is the most important way to increase efficiency and to have a strategic advantage. Also high value is taken by entrepreneurial thinking skills which lead to open doors for new opportunities, the competencies related to research skills didn't take a high value that could be as a result of lack of

	Managerial competencies	Arithmetic mean	Standard deviation
1	Creativity	3.71	0.92
2	Entrepreneurial thinking	4.57	0.53
3	Problem solving	4.25	0.71
4	Conflict solving	4.25	0.71
5	Decision making	4.57	0.92
6	Analytical skills	4.13	0.35
7	Research skills	2.38	1.51
8	Efficiency orientation	4.50	0.53

Table 3.1 Assessment of Managerial competencies in the automotive sector for Industry 4.0

innovation toward development and research skills. Therefore, the greatest diversity was shown in the assessment of research skills.

3.1.3 Automotive skills policies to meet industry 4.0

Manufacturing executives realize that Industry 4.0 is revolutionizing the factory of the future, but there is a widening gap between the required and the existing skills. The fourth industrial revolution demands significant change. New ways of working, new skills and capabilities, new operating models, and new roles and responsibilities will be required. As, the biggest challenge is people. Good strategies and policies must be taken to acquire and retain the skills needed to operate in the Industry 4.0 environment. So, the main actions need to be taken to enhance industry 4.0 to cope with the automotive sector are the following,

1. Try to bring new talent to the industry as smart factory employees will need to be comfortable with computers. The challenge will be finding those with an advanced skill set.

2. Engage new forms of learning to integrate comprehensive skills development approaches and innovative training schemes into corporate strategies.

3. Focus on the team work and the ethical issues to increase the security of data because Industry 4.0 calls for opening the loop, which makes every manufacturing enterprise vulnerable to cybersecurity threats.

4. Increase knowledge about 3D printing, robotics, and IT which can aid OEMs to enhance product design and transform traditional production and supply chain inefficiencies.

5. Programs to learn how to deal with machines especially when they are out of date when smart technologies can't optimally integrate with them.

Finally, the previous mentioned skills are divided into main categories, soft and hard skills, as shown in Table 3.2.

Automotive sector	
Soft Skills	**Hard Skills**
Creativity	Advanced Product Quality Planning (APQP)
Problem solving skills	Failure Mode and Effects Analysis (FMEA)
Conflict resolution skills	Measurement Systems Analysis (MSA)
Decision making	Statistical Process Control (SPC)
Leadership development skills	Product Part Approval Process (PPAP)
Analytical skills	programming skills
	Robotic skills
	3D printing skills

Table 3.2 Hard and soft skills of workers in Automotive industrial sector

3.2 Food sector and Industry 4.0

Increasing connectivity is propelling the food sector into a new digital age, there is important scope for transformation, not only in the production process through increased automation and the reduction of waste, but also in the development and introduction of new products — with an increased use of technology providing the flexibility to run prototypes and bring new products to market at the same time.

3.2.1 Benefits of Industry 4.0 for the Food Sector

The benefits of technological progress will be seen across the organization of the food industry such as the following:

1. The ability of Smart processes to be run with minimal human intervention, so that will decrease labour cost.
2. Make autonomous adjustments with operations using smart components based on the data collected from the plant floor.
3. Decrease number of defects and errors as a result of less human intervention, resulting in higher-quality products, less room for error, and increased customer satisfaction.
4. New functionality will be gained from increasing use of automation and robotics, such as flexibility in changeover and operator safety, self-diagnostics for preventive maintenance, and more connectivity and interoperability between systems.
5. Recall and trace ingredients: Using new technology will create a better and more integrated supply chain.
6. Increase safety and efficiency: Through 3D printing, prototypes no longer take weeks to produce. They can be done in a matter of days, resulting in reduced consumer testing times.

7. Optimise the workforce: Machines are becoming more equipped for performing a wide range of cognitive and physical tasks. This could potentially increase the level of automation, reduce labour costs and reduce waste costs associated with human error.

8. Identify opportunities and increase output: can achieve real-time visibility across all different operations by implementing a system where data collection is automated and centralised.

Despite all these advantages one major challenge will most certainly be recruiting, upskilling, and keeping staff capable of maintaining these highly complicated business operations. Surviving and thriving in the era of Industry 4.0 will entail more than just investing in technology. It will mean investing in people as well. Manufacturers will need staff properly trained in safe, systematic, electrical troubleshooting that resolves problems swiftly, eliminates guesswork, and prevents further accidents. To compete, businesses are going to have to invest in their people, giving them the necessary skills to handle complex, data-rich, integrated systems; skills such as analysing and interpreting data, and troubleshooting electrical problems.

3.2.2 Skills and Competencies of worker in food industry for Industry 4.0.

Technology is rapidly transforming food manufacturing with the introduction of robotics automation and artificial intelligence. Thus, employees will need new training to expand their expertise and enhance their technical skills. The main skills and competencies that are required based on [16] are:

1. Mechanics & Machine Maintenance: Jobs now require more up-to-date knowledge of lean manufacturing processes, work measurements, facilities design, and process controls.

2. Electronics & Computation: With automation involved into the production line, its important to have the ability to use specific computers

proficiently and operate sensory systems, and to make important decision if machines malfunction.

3. Food Safety: requires food manufacturers to handle recalls efficiently, develop new ways of testing and keeping food safe, and prevent large-scale adulteration.

4. At a higher level, food manufacturers require programmers' skills which can assist operations, interface with consumers online, and manipulate data.

5. Problem Solving skills: Food service operations are fast-paced with little room for error, and machine supervisors need to be able to solve complex problems on the fly, especially with the new machines and technology of industry 4.0.

6. Performance Monitoring and Assessment: managing robotic working or monitoring tasks that machines do is important to check the works and if there is any problem that need to be fixed.

7. Good communication skills: as industry 4.0 open the door for more data via internet food and customer services become various, so communication between workers will be need to gain more efficient work.

8. Positive attitude and initative :food sector is critical one as the new technology make the integration between customer and worker more direct , so workers need to be positive and more initative at all situations.

9. A Willingness to Learn: the workers in the food sector need to be more responsible and try to adapt the collaborative learning to deal with the new technology of industry 4.0.

3.2.3 FOOD skills policies to meet industry 4.0

Manufacturing executives realize that Industry 4.0 is revolutionizing the factory of the future, but there is a widening gap between the required and the existing skills. The fourth industrial revolution demands significant change. New ways of working, new skills and capabilities, new operating models, and new roles and responsibilities will be required. As, the biggest challenge is people. Good strategies and policies must be taken to acquire and retain the skills needed to operate in the Industry 4.0 environment. Therefore, the main actions need to be taken to prepare for industry 4.0 are:

1. Increase the knowledge about Digitization of agriculture which will promote the creation of prescription maps for the fertilization, protection and use of water and how to use innovative statistical models.

2. Make continues training for packaging, processing machines, equipment, and how to deal with innovative systems for integrated logistics.

3. Different programs to learn how to analyse Big-data to define optimization strategies.

4. Create courses for advanced programming and improving logistics to develop new products.

5. Provide thorough and continuous training to help new and existing workers understand and internalize the disciplines involved with data-driven, automated work-flows, and the importance of responsible data stewardship

6. It is necessary to increase the entrepreneurship of students and researchers, promoting and improving the quality and quantity of the research groups of excellence also co-operation between universities, research and industrial players is essential.

Finally, the previous mentioned skills are divided into main categories, soft and hard skills, as shown in Table 3.3.

Food sector	
Soft Skills	**Hard Skills**
Problem solving	Mechanics & Machine Maintenance skills
Communication skills	Electronics & Computation skills
Positive attitude and imitative skills	Food Safety skills
A Willingness to Learn	Hygiene Skills
Stress management skills	Statistical model skills
Work ethic skills	Performance Monitoring and Assessment skills
	Programming skills
	3D printing skills

Table 3.3 Hard and soft skills of workers in Food industrial sector

3.3 ICT sector and Industry 4.0

ICT has a plethora of new technologies including Cloud Computing, Big Data and Internet of Things (IoT) that are enhancing automation, and driving increased digitalization, networking and connectivity; resulting in increased levels of industrial intelligence. Industry 4.0 is a paradigm that will see machines collaborating seamlessly and performing increasingly complex tasks; accurately predicting downtimes and failures, and triggering maintenance processes; and perhaps even 'self-organizing' themselves to respond to unscheduled disruptions in the production line [52].

Large proportion of people do not effectively use digital technologies at work or do not have adequate ICT skills. The OECD's Survey of Adult Skills [25] indicates that on average more than half of the adult population can only perform the simplest set of computers tasks or have no ICT skills at all. Only about one third of workers have the skills to evaluate problems and find solutions. Because of that the demand for ICT professionals is exceeding supply as shown in figure 3.17.

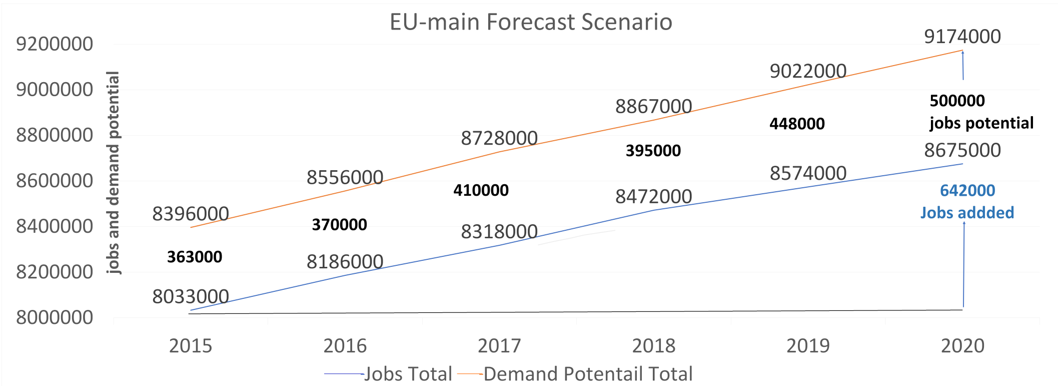

Figure 3.17 Demand for ICT professionals is exceeding supply (Empirica 2017)

3.3.1 Benefits of Industry 4.0 for the ICT Sector

The emerging advances of industry 4.0 like sensors system, automation, Big Data and IOT along with ICT will open new possibilities for lifelong learning utilizing data from production, ICT and Industry 4.0 will create new way of education and knowledge. Based on [60], there are versatile benefits to support ICT sector and they are summarized as follows:

1. Develop new learning systems which is transformed because of specialization of the work by industry 4.0 and that need new form of supervision, guidance and collaborative learning, mediated through ICT tools.

2. New potentials for on-the-job, individual workplace learning, from e-learning schemes to advanced serious games by the connection of industry 4.0.

3. Access to more data and knowledge of industry 4.0 Increased the efficient learning as Adaptive learning and individually tailored learning path.

4. Industry 4.0 opens the loop for more data that create more opportunities for critical thinking and analytical approaches for new ICT learning paradigm.

5. A growing number of social networks lead to share infinite amounts of multi-media learning resources in future Industry 4.0 learning.

6. Industry 4.0 cyber-physical manufacturing systems create virtual classrooms, opening for unsynchronized social learning.

3.3.2 Skills and Competencies of workers in ICT Industry for Industry 4.0

Increasing use of digital technologies at work such as ICT products and services – software, web pages, ecommerce, cloud and big data is raising the demand for new skills. There should be a greater focus on skills that are transferable – and that enable the development of high levels of technical capability underpinned by a strong foundation of broad based vocational knowledge.

The main type of ICT skills and there purposes can be summarized as follows (see also Table 3.4):

1. Technical and professional skills, including ICT specialist skills for programming developing applications and managing networks that will drive innovation, support digital infrastructures and the functioning of the digital eco-system

2. ICT generic skills: skills that build a broader set of 'capabilities' that can be rapidly applied to other work environments by using different

technologies for professional purposes such as access information online or using of software. Moreover, the major kinds of generic skills are classified as follows,

- thinking skills: such as problem-solving techniques,
- learning strategies: to help you remember things,
- metacognitive skills: such as monitoring and revising the problem solving techniques.

3. ICT complementary skills, to perform new tasks associated to the use of ICTs at work, e.g. communicate on social networks, brand products on e-commerce platforms, analyse big data, leadership and teamwork skills.

Types	Purpose
ICT generic skills	To perform everyday work, such as work with word processors and access websites.
ICT specialist skills	To program, develop applications, and manage networks
ICT complementary skills	To perform multiple and aggregated tasks, such as processing complex information, communicate with others, solve problems, and manage a team.

Source: OECD, 2016

Table 3.4 Main ICT Skills for Industry 4.0

3.3.3 ICT skills policies to meet industry 4.0

Manufacturing executives realize that Industry 4.0 is revolutionizing the factory of the future, but there is a widening gap between the required and the existing skills. The fourth industrial revolution demands significant change. New ways of working, new skills and capabilities, new operating models, and new roles and responsibilities will be required. As, the biggest challenge is people. Good strategies and policies must be taken to acquire and retain the skills needed to operate in the Industry 4.0 environment. Therefore, the main actions need to be taken to to enhance industry 4.0 to cope with the ICT sector (according to [25]) are the following,

1. Promote better team work organization and management practices within firms and across the economy.
2. Recognize basic ICT skills as well as solid literacy, numeracy and problem-solving skills which can be acquired outside formal channels.
3. Continues training to re-skill and up-skill by keep up with new skill requirements.
4. Reintegration programs for uneducated or unskilled people.
5. Second-chance programs which focus on basic and complementary ICT skills promoted by the European Union, or those in Canada, France, Ireland and the United States.
6. Create labour market programs for job seekers who are facing difficulties because of outdated or inadequate skills.
7. Develop the courses quality and Increase the incentives to use them like MOOCs (massive open online courses) and OERs (open educational resources) which are still underutilized.
8. Alternative certification methods (e.g. Open Badge) have begun to appear (ITU, 2014). Several technology companies such as Microsoft, CISCO, HP, Samsung, Apple, and Google, offer certificates that MOOC participants can earn directly online. Technology also offers prospects of new ways to learn skills, such as using virtual reality, games and so forth.

Finally, the previous mentioned skills are divided into main categories, soft and hard skills, as shown in Table 3.5.

ICT sector	
Soft Skills	**Hard Skills**
Problem solving skills	Programming
Team management	Software and app development
Communication	Network management
Flexibility skills	Complex information processing
Mentoring and Listening skills	Website access
Negotiation skills	Big Data analytics
	In-memory database
	Digital security skills

Table 3.5 Hard and soft skills of workers in ICT industrial sector

Chapter 4: Summary and Conclusion

In the previous chapters, we introduced the skills development of workers needed for the industry in European commission in general. Then, we focused on three sectors, Automotive, Food and ICT sector to understand the knowledge, competencies, and attitudes of the workers that will be needed in each sector. After that, a classification of enterprises and comparison of the characteristic of small, medium and large enterprises were introduced. On the other hand, we discussed the effect of industry 4.0 on the skills and knowledge of the three main sectors employee and the benefits of industry 4.0 on each sector. Finally, the main skills that will be needed to keep up with this new technology and the skills policies that can be taken to improve the knowledge and the competencies of the workers in these sectors were discussed. Therefore, the aim of this chapter is to summarize and conclude the main results that we analyzed in this report.

In particular, in Chapter 2, we concentrated on different industrial sectors to understand the knowledge, competencies, and attitudes of the workers for different sectors, which can be summarized in Table 4.6.

Although Small and Medium managers have very good experience on manufacturing processes but efficient management of the technological data is the main issue in Small and Medium sized Enterprises and therefor this will increase the need for an efficient management to support and solve technological data problem. Moreover, in the large enterprises the plenty of resources and information more than SME open the opportunity for more valuable improvement in innovation capabilities and business process (for more details see Table 4.7). Finally, the preferences of enterprises will depend on the industrial sector as each enterprise has challenges and opportunities.

From chapter 3, we notice that the main issue for most firms today turns out to be the recruitment, tenure and training of people with the appropriate skills rather than the adoption of a particular technology, Workers will need different skills, not just more skills .Moreover, as technology becomes more advanced and more complex skills such as scientists, ICT professionals and engineer which is called STEM (Science, Technology, Engineering and Mathematics)skills will be required [46].

The rapid advancement of the Fourth Industrial Revolution with its associated technologies will transform the nature of work. The 'Top 10 skills' listed by the World Economic Forum in 2015 are anticipated to change by 2020 (see figure 4.18). While 'Complex Problem Solving' remains at the top, "Critical Thinking', 'Creativity', 'Emotional Intelligence' and 'Cognitive Flexibility' will become increasingly important [34].

in 2015	in 2020
Complex Problem Solving	Complex Problem Solving
Coordinating with Others	Critical Thinking
People Management	Creativity
Critical Thinking	People managment
Negotiation	Coordinating with Others
Quality Control	Emotional Intelligence
Service Orientation	Judgment and decision making
Judgment and decision making	Service Orientation
Active listening	Negotiation
Creativity	Cognitive Flexibilty

Figure 4.18 The 'Top 10 skills' listed by the World Economic Forum in 2015

In Table 4.8 we summarize the Skills and competencies that are required for workers in each sector to match with Industry 4.0 technology. In this table, skills are divided into two categories: Soft and Hard skills. Soft skills: is a term used to refer to the more intangible and non-technical abilities that is related to the attitudes and intuitions of the worker. Furthermore, Soft skills relate to how the employee work with others whereas hard skills relate to the employee, in isolation, as an individual. Therefore, soft skills are harder to quantify and less often taught formally in schools and vocational programs. On the other hand, Hard skills: are the tangible and technical skills easily demonstrated by workers qualifications and specific professional experiences. Moreover, Hard skills are acquired through formal education and training programs.

It's worth noting that, both of hard and soft skills need to be emphasized on the employee before start working, especially, with the new technology of industry 4.0. Therefore, introducing the skills reported in Table 4.8 become more important and necessary to increase both the productivity and the healthy work environment.

Despite that industry 4.0 will increase the use of robotics, machines and automation technologies, the need for worker is still very important to control and manage all these technologies to create more efficiency and profitability for the industry. However, as the nature of work is different between sectors this will imply that skills and knowledge will be different to cope with these differences as shown in Table 4.8.

Finally, we can say that, Industry 4.0 presents different benefits and opportunities for various sectors. However, Industry 4.0 raise a severe threats and challenges in e.g., business models, Recruiting and developing new talent, skill requirements shift and the interconnection of all departments, were we can see major changes in top positions, at both the company and regional levels. Therefore, the aim of this report was to analyse the skills, knowledge and competencies of worker that will be needed to cope with the revolution of Industry 4.0 in the E.C along with the skills policies and actions that are needed to decrease the gap of the required skills in different industrial sectors.

Table 4.6 Comparison: competencies, attitudes and knowledge

Sectors	**Competencies**	**Attitudes**	**Knowledge**
Automotive sector	Motivate members to participate and contribute knowledge to the collective good as knowledge sharing network	People learn in different ways such as problem-solving exercises and peer-to peer learning	Qualifications in different subjects by vocational training
	Mixing of employees with different levels of experience and from different age groups	Development of professional and personal skills	Knowledge and experience of retired employees which is necessary to be transferred before retiring
	Knowing how to effectively communicate changes in an organization	Employees need to love their work and have work ethic, Confidentiality Employers and Industry Familiarity	Technical employees, Problem-Solving Skills, analytical-minded
ICT sector	Communication network	Flexibility and creativity	Digital Literacy ,ability to access or use ICT
	Understand the needs for critical evaluation of internet information	Care and attention to the safety with ICT	Knowledge about telecommunication networks, information processing, programming languages and internet technologies
Food sector	Knowledge acquisition by employees	High motivation to work	Local scientific and technical skills
	Ability and willingness to learn	Healthy food awareness	Hygienic handling of food and nutrition education
	Communication with other workers	Key trend for improvement the food lifestyle	Knowledge of the dangers of contamination, storage, preparation of food

Table 4.7 Comparison: small, medium and large enterprises

	Small companies and medium-sized enterprises	**Large enterprises**
Number of employees	Small companies: fewer than 50 employees but medium size: more than 50 but less than 250 employees	More than 250 employees
Ability to gain knowledge	Knowledge constraints	Easier to gain more knowledge
Adoption of changes	More vulnerable to the environmental effects and misjudgements	Hard to adopt the changes in enterprise resource planning
Plenty of resources	Limited access to resources such as time, skills, and money and lower adequacy of information for decision-making	More resources and information rather than SME
Way of adjustment	Allocate more time for adjusting because of limited resources	Predicting and controlling, the turbulence they are faced with
Need of Skills	Limited management skills needed	More skills requirements
Technological development	Can't adopt the technology up to date because of resource constraint	Up to date technology as more resources in the large enterprises
Strategic thinking	Long life investment and day to day survival	Along-range strategic thinking
IT/IS adoption	Adoption, implementation, and management of IT/IS is harder	Easier rather than SME
Policies requirement	Less established structures and policies and thus more flexibility	More complicated rather than SME
IT/IS investments	Day to day survival emphasis on efficiency, cost reduction, and automation in IT/IS investments	The strategy doesn't focus on day to day so less efficient in large enterprise
Innovation capabilities	Incremental approach to IT investments so the improvement is not valuable as large enterprises	More valuable improvement in innovation capabilities and business process

Automotive Sector		Food Sector		ICT Sector	
Soft Skills	**Hard Skills**	**Soft Skills**	**Hard Skills**	**Soft Skills**	**Hard Skills**
Creativity	Advanced Product Quality Planning (APQP)	Problem Solving	Mechanics & Machine Maintenance Skills	Problem Solving Skills	Programming
Problem Solving Skills	Failure Mode and Effects Analysis (FMEA)	Communicati on Skills	Electronics & Computation Skills	Team Management	Software and App Development
Conflict Resolution Skills	Measurement Systems Analysis (MSA)	Positive Attitude and Initiative Skills	Food Safety Skills	Communication	Network Management
Decision Making	Statistical Process Control (SPC)	A Willingness to Learn	Hygiene Skills	Flexibility Skills	Complex Information Processing
Leadership Development Skills	Product Part Approval Process (PPAP)	Stress Management Skills	Statistical Model Skills	Mentoring and Listening Skills	Website Access
Analytical Skills	Programming	Work Ethic Skills	Performance Monitoring and Assessment Skills	Negotiation Skills	Big Data Analytics
	Robotic		Programming Skills		In-Memory Database
	3D Printing		3D Printing Skills		Digital Security Skills

Table 4.8 Soft and Hard Skills and competencies for industry 4.0 for different industrial sectors

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