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SKILLS MISMATCH IN TRANSITION TO INDUSTRY 4.0 IN THE CONTEXT OF LARGE-SCALE MANUFACTURING INDUSTRIES IN TÜRKİYE

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ABSTRACT

The present study addresses skills mismatch in large-scale manufacturing industries adopting Industry 4.0 technologies in Türkiye. Therefore, the primary aim is to reveal the reasons for the skills mismatch in large-scale companies utilizing digital technologies. In this qualitative study, we held face-to-face interviews with 41 senior managers, human resources directors, and experts undertaking the Industry 4.0 process in 19 large-scale manufacturing companies operating in seven provinces of Türkiye (Istanbul, Ankara, Izmir, Izmit, Kayseri, Bursa, and Gaziantep). The findings demonstrated four main categories to discuss the reasons for skills mismatch in the companies in the transition to Industry 4.0: difficulties in labor supply, difficulties in retaining the labor force, labor force's adaptation to Industry 4.0, and the emergence of novel business models.

Keywords: *Industry 4.0, Skills Mismatch, Labor Market, Manufacturing Industry, Labor Force Skills.*

Jel Codes: *J21, J22, J24.*

1. INTRODUCTION

The ever-increasing adoption of Industry 4.0 technologies thanks to the digital transformation in manufacturing industries seems to raise an alarming need for labor force skills. Thus, emerging technologies may be claimed to lead employers to brood over finding talents with suitable competencies for vacancies (Randstad, 2020), which is mediated by four significant factors. First, the increasing role of automation technologies has recently transformed at least half of conventional professions into automatable tasks (Manyika et al., 2017); thus the ability of employees to continue adding value to companies highly depends on their ability to acquire novel skills. Second, the labor supply becomes quite limited for specific fields (artificial intelligence, data analytics, blockchain, etc.). Third, the

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increasing use of smart machines has introduced new roles and needs in areas such as networking, management, and device troubleshooting. Finally, it is anticipated that 20-50 million new tech jobs will be created worldwide by 2030, even though rapidly advancing technologies make it blurred to predict what skills will be needed in the future (McKinsey, 2017).

Globalization reinforces the comparative advantage of thriving economies in goods and services produced with highly-skilled labor. Nevertheless, the gradual reallocation of the labor force to industries demanding diverse skill sets can lead to skills shortages with the decline in medium-skilled jobs. The extent to which this situation can happen relies on the intensity of the adaptation shock, the skills pool, and the possibility for (re)deployment of those skills in the labor force. The shift in labor demand toward more skilled jobs and the aging of the population pose skills shortages and mismatches, partly because older workers have already acquired skills not closely matched with digitalization-rooted skills in modern economies.

Technological changes are also considered a factor that triggers sectoral dynamics and causes skills shortages, as compelling needs for new skills will not immediately be available in the labor market until the education system (including employer training) can satisfy the requirements of such skills. Moreover, companies operating in rapidly changing markets may favor employing those with higher qualifications to facilitate labor force adaptation (Desjardins and Rubenson, 2011).

Recent technological advancements have been characterized by the unprecedented spread of information and communication technologies. Such a conjuncture has resulted in an acceleration in demand for skilled employees, exceeding the available supply (Acemoglu and Autor, 2011; Katz and Autor, 1999). On the other hand, the decrease in the demand for routine cognitive and manual tasks has boosted the dependence of production on non-routine tasks that cannot be easily automated. Thus, job polarization - the simultaneous increase in the share of low-skilled and high-skilled occupations and the decrease in the share of middle-skilled jobs - has emerged (Autor et al., 2003). The most significant outcome in the above structure may be that technological advancements lead to skills mismatch becoming widespread. The economic costs of skills mismatch and shortages affect individuals, firms, and, thus, the overall economy. The costs for individuals may be persistent lower wages and poorer skill development, while those for companies include lower productivity and higher job turnover, as well as hiring and training costs. The costs for the overall economy, on the other hand, cover efficiency losses associated with the suboptimal allocation of resources - lower average productivity and higher unemployment (Garibaldi et al., 2020).

This study focuses on the workforce skills of large-scale companies operating in Türkiye that have started to use digital technologies. The main purpose is to determine how the skill mismatch problem in the workforce is progressing with the digital transformation. In this context, the reasons for the skill mismatch of the workforce in the companies in question were analyzed within the framework

of the interviews of the top managers of the companies. The tendency of digital transformation in Türkiye to be new in the academic literature still continues. Therefore, an important part of the studies carried out is only a literature review. However, in this study, the problems experienced by these companies regarding the workforce in the digital transformation process were discussed by interviewing the top managers of Türkiye's leading companies. The fact that the subject of digital transformation is still a new subject in Türkiye highlights the exploratory feature of this study. In this context, the main question of the study is: What are the reasons for the labor-skill mismatch experienced as large-scale companies in Türkiye start to use digital technologies in their production processes? Industry 4.0 technologies have the potential to deepen the skill mismatch that has existed in Türkiye from past to present. Therefore, this study emphasizes the necessity of equipping the human resources in Türkiye with skills that can easily adapt to Industry 4.0 technologies by revealing the reasons for the skill mismatch. In this context, the study has a unique quality in terms of contributing to the literature for this purpose.

In the first part of the study, a literature review on the skill mismatch of the workforce is included. In the second part, there is detailed information about the methodology of the study and the participants. In the findings section, there is a descriptive analysis of the data obtained as a result of the study.

2. LITERATURE REVIEW

Categorized as cognitive (e.g., literacy or math skills) and non-cognitive skills (e.g., physical or soft skills), skills can be conceived of as the human capital of an economy. It was previously concluded that cognitive skills are positively linked with one’s achievement in the labor market, social involvement, and financial growth. At the individual level, promoting skills may enable one to better understand job-related processes, perform better, and contribute to economic cycles. Thus, such a productivity-enhancing effect of skills may then contribute to one’s wage or play a protective role against unemployment (Hanushek et al., 2014). At the macroeconomic level, exceptional skills lead to faster technological advancements and facilitate technology adoption (Perry et al., 2014).

When utilizing their skills efficiently, one may earn enough, which, in turn, encourages economic growth (OECD, 2012). However, today the incongruence between the skills/qualities demanded by the labor market and offered by a particular education system has become a compelling issue in the labor market in many countries, which can be denoted as a skills mismatch. This situation is expressed by skill mismatch. The concept of skills mismatch occurs when employees' skills are inferior or superior to those required in the workplace. In this regard, while superior skills than needed refer to a skills surplus, inferior skills correspond to a skills shortage (Quintini, 2011).

Current theoretical debates on skill mismatch are generally based on two approaches (Desjardins and Rubenson, 2011; Lloyd and Payne, 2002). The first is the theoretical approach that attributes skills mismatch to the supply side, which includes governments, education and training institutions, and

individuals. This supply-side approach, grounded on human capital theory, explains how market failures and skills mismatch hinder the skill supply from responding to employers' demand for skills (Almeida et al., 2012). In addition, current research on this approach emphasizes that skills shortages and gaps are widening due to the increasing demand for skills with technological advancements. This argument relies on the theory of "skill-biased technological change" advocating that new technologies and changes in production methods and organizational affairs would increase the demand for highly-skilled labor over less-skilled labor. In the supply-side approach, skill shortages and skills gap are often attributed to the inadequate performance of education and training institutions (Brown et al., 2001). Therefore, governments are advised to develop formal and informal curricula in line with employers' growing demands for skills (ADB, 2009). However, the second approach attributes skills issues not only to the supply side but also to the demand side, focusing on employers' demands and skills use. This 'demand-driven approach' has emerged from research on the political economy of skills formation, which raises questions not only of economic competitiveness but also of social purpose and justice (Ashton et al., 1999).

Ada, Ilic, and Sagnak (2021) state that radical changes and developments linked with global connectivity, automation trends, and technological innovations generate different business demands thanks to Industry 4.0, which mandates human resource managers to reconsider diverse skills in recruitment and other human resource functions. In their study, they attempted to propose a framework for a skill set required for recruitment in the age of Industry 4.0, analyzed the significance of different skill categories, and presented a roadmap to human resources managers. Accordingly, they concluded project management to be the most potent skill in modern industries, followed by financial management, technology-based skills, digital literacy, literacy, innovation, and creativity. Akyazi et al. (2020) created an automated database of competencies and skills in future professions with Industry 4.0 and argued that this database would become an essential tool to provide well-developed and better-directed continuing education programs to reduce the skills mismatch between the labor force and jobs. Karacay (2018), on the other hand, emphasized that business processes may need to be redesigned to create the labor force of the future not only to attract and develop new talents but also to re-skill current employees through education programs and reduce the skills mismatch between jobs and employees. Goher et al. (2020) investigated the skills mismatch introduced by Industry 4.0 and demonstrated that the mismatch between skills and education is prevalent in the private and public industries in the United Arab Emirates (UAE). They noted that the nature of skills mismatch is rooted in a skills gap and that the most common type of educational mismatch in the UAE is a horizontal mismatch. Their findings also showed that engineers are among the groups that are the most affected by both skills and educational mismatch and that most of the engineers, indeed, are not employed in engineering jobs. Braun et al. (2022), on the other hand, pointed to a growing skills gap among workers in manufacturing industries. The findings

highlighted that skills remain insufficient to meet the needs of the labor force in the face of rapid technological developments.

Flores et al. (2020) predicted a significant change in human capital in the future of Industry 4.0 and proposed a human-oriented perspective for companies within the new Industrial Revolution. In the study, they presented three options for Industry 4.0 and the labor force: The design of a labor force with unique interactions, new terms embracing the human capital of the future, and a typology for competencies mandated by Industry 4.0. In their study, Özkan-Özen and Kazancoglu (2021), in their study, aimed to design a structural model that would reveal the challenges of workforce development in the digital age. Overall, they concluded that the lack of IT/digital skills has the capacity to pose challenges in workforce development.

Grenčíková et al. (2021) uttered that new jobs would emerge and that employers would demand digital skills and abilities from their employees to capitalize on Industry 4.0, which inevitably mandates considerable changes to instructional techniques in education institutions. It is then necessary to adopt a broader perspective instead of specialization in a single field since potential employees need to acquire interdisciplinary thinking. In their study, the aim was to uncover the Industry 4.0-related domains that organizations should focus on in the future. Accordingly, the findings revealed that the changes to the Industry 4.0-related competencies of the labor force should contribute to boosting companies' competitiveness and production efficiency.

Technological advancements that fuel productivity in businesses have led to a change in the skills demanded from employees. One way economies can reap the benefits of the digital revolution may be to focus on appropriate skills mandated by such a revolution. In their study, Janeska and Lozanoska (2021) traced the impacts of digitalization on the labor market in North Macedonia and concluded that digitalization may not become the leading factor for job losses. However, the authors noted that digitalization may lead to significant changes in the employment structure (i.e., sectors, professions, skills, nature of jobs, and pressure on lower skills). They also pointed out that digitalization may reduce aging-driven labor force shortages.

The study by Zhurukov (2020) aimed to reveal an understanding of the skills demanded by employers but not addressed in formal education so far and to propose a ground for adaptive education regulation that would raise the level of higher education in Finland. The results showed that employers often demand basic field-specific literacy, competencies, and traits. In another study, employers emphasized that potential employees should improve all their skill sets through lifelong learning courses, including basic literacy, competencies, and traits.

In their study, Jandrić and Ranđelović (2018) identified the degree of adaptability of labor force skills. Accordingly, they concluded that European states can be grouped into three regarding adaptability: High performance (Northern and Western Europe), moderate performance (Central Europe

and the Baltics), and low performance (South and Southeastern Europe). It was also noted that the poor adaptability of the labor force may become a significant barrier to further growth and development for some countries.

A sustainably performing economy cycle depends on human capital-generating gear and is ensured by a sufficient number of people with relevant knowledge and skills to perform the tasks. The smooth functioning of the labor market relies on balancing supply and demand for skills, which in turn matches employees with vacancies (Weaver and Osterman, 2017). In fact, what needs to be considered may be the discrepancy between the labor force's knowledge/skills and responsibilities rather than the lack of labor force. Today, 1.3 billion people have either superior or insufficient competencies for the activities they perform, and this number is estimated to exceed 1.4 billion by 2030 (BCG, 2020).

Thulasy et al. (2022) explored skill set issues in aircraft maintenance from the context of Industry 4.0. According to the findings, firms should foster a culture of continuous learning and develop a mindset among their employees that allows them to adapt to new technologies and knowledge in aircraft maintenance. McGuinness et al. (2023) noted that, despite recent focus on the polarizing effect of automation and the requalification needs of low-skilled individuals, technological change predominantly affects more highly skilled workers and reinforces inequalities in opportunities for upskilling in the workplace. This study also provides evidence that technological change is associated with employee upskilling dynamically. In their study, Landsberg and van Berg (2023) evaluated the accounting module documents of the best universities in South Africa to determine whether the curriculum meets the workforce needs of Industry 4.0. Findings from a systematic literature review show that universities adequately address business intelligence skills; however, the categories of digital, relational, and decision-making intelligence are not sufficiently prominent in the current curricula of the top five South African universities. According to Gangoda et al. (2023) explores how digitization and automation transform the skills required by the workforce, as well as examining how the workforce of the future can be trained. The findings show that intellectual, innovative and creative jobs will be in significant demand in the future of AI and automation. The results show that digital and technical skills rather than social skills should be emphasized in employee training.

Primarily by complementing or replacing employees, digital technologies have a significant impact on the labor market, triggering a shift in the skill sets demanded from employees with a greater focus on problem-solving skills, creativity, socio-emotional skills, functional literacy, and technical skills. The future impacts of digitization on the labor market and economic performance of any country depend on labor force adaptation, industrial and professional structure, alignment of skill sets, organization of work, and the current state of digitization.

3. METHODOLOGY

The present qualitative study aimed to trace the causes of skills mismatch in the labor market based on the views of senior managers, professionals, and digital transformation experts from Türkiye's top 500 large-scale manufacturing companies (ISO 500) that adopt Industry 4.0 technologies. In this regard, we held face-to-face interviews with 41 participants consisting of senior managers, human resources directors, and experts implementing the Industry 4.0 process of 19 manufacturing companies operating in seven provinces of Türkiye.

Creswell (2016) recommends utilizing a qualitative research design in discovering a problem and/or phenomenon. According to Yıldırım and Şimşek (2016:41), qualitative design is "a research method where the data are collected using qualitative techniques (e.g., observation, interviews, and document analysis), and a realistic and holistic qualitative process is followed to reveal perceptions and events in their typical settings." This design often provides researchers with flexibility in discovering events. Exploratory research, which is a qualitative research method, is generally preferred to diversify and elaborate the data collected from the field. In addition, it can be utilized in situations that have not been studied before or where data collection may be partially difficult (Bengtsson, 2016).

We selected the participants using the maximum variation sampling to ensure representativeness and maximize the diversity of the people thought to be parties to the research problem. Yet, this sampling technique is not to generalize the findings but to reveal any shared phenomena in different situations and reflect different aspects of the problem (Yıldırım and Şimşek, 2016). We interviewed the participants in 19 companies within large-scale manufacturing industries in seven provinces of Türkiye (Istanbul, Ankara, Izmir, Izmit, Kayseri, Bursa, and Gaziantep). Besides, we tried to select the participants from companies operating in different industries for two main reasons: To describe specific aspects of each situation in detail and to reveal the common themes between cases with vastly different characteristics.

As mentioned above, we collected the data using a semi-structured interview technique (Magilvy and Thomas, 2009) since semi-structured interviews often provide researchers and participants with substantial flexibility (Miguel, 2011) and function as a guide for the subject investigated. Prior to face-to-face interviews, the participants were sent a semi-structured interview form with a research information leaflet. We then conducted the scheduled interviews with the participants either in the manufacturing facilities or the companies' headquarters. The Ethics Committee of Ankara Yildirim Beyazit University granted ethical approval to our study (2019).

We recorded the interviews with a voice recorder upon the participants' permission and deciphered them in the NVivo 12 qualitative data analysis program to perform relevant analyses. Wolcott (1994) emphasized that qualitative data analysis needs to rely on the original form of the data collected and that what the participant uttered should be quoted directly when necessary. Qualitative

descriptive research "generates data that describe the 'who, what, and where of events or experiences' from a subjective perspective" (Kim et al. 2017: 23). In this study, we followed a data analysis process consisting of deciphering recordings, reading and rereading transcriptions and field notes, identifying codes, and classifying them by categories and themes (Magilvy and Thomas, 2009).

When it comes to the participants' demographic characteristics, we held interviews with 41 participants - 17 males and 24 females - aged between 24 and 61 years with a seniority of 1-40 years. While 28 participants held an engineering degree, 13 graduated from an undergraduate program in economics and administrative sciences. The participants' professional characteristics are presented in Table 1.

Table 1. Participants' Professional Characteristics

Participant	Industry	Title/Unit	Participant	Industry	Title/Unit
P1	Home Appliances	Technology Director	**P23**	Food	Human Resources Manager
P2	Aluminum	Senior Human Resources Manager	**P24**	Food	General Manager
P3	Aluminum	Electrical Automation Manager	**P25**	Food	Factory Manager
P4	Aluminum	Investment Director	**P26**	Defense	Production Planning Leader
P5	Automotive	Internal Communications and Employee Experience Manager	**P27**	Defense	Human Resources Leader
P6	Automotive	Recruitment Manager	**P28**	Food	Human Resources Specialist
P7	Automotive	Production Planning, Material Planning, and New Projects Group Manager	**P29**	Food	Human Resources Partner
P8	Furniture	System Development Manager	**P30**	Food	Human Resources Manager
P9	Furniture	Factory Manager	**P31**	Defense	Career and Talent Development Manager
P10	Tire	Virtual Chief Technical Officer (VCTO)	**P32**	Defense	Recruitment Specialist
P11	Tire	Human Resources Corporate Development Director	**P33**	Defense	Recruitment Manager
P12	Automotive	Innovation and Technology Manager	**P34**	Defense	Design Engineer
P13	Automotive	Senior Human Resources Manager	**P35**	Machinery	Research and Development and Technical Support Manager
P14	Automotive	Design Group Manager	**P36**	Machinery	Vocational Training Manager

P15	Steel	Human Resources Corporate Development Director	**P37**	Machinery	Human Resources Specialist
P16	Steel	General Manager	**P38**	Machinery	Human Resources Manager
P17	Automotive	Assistant General Manager	**P39**	Medicine	Senior Human Resources Manager
P18	Defense	Human Resources Business Partnership Specialist	**P40**	Automotive	Industry 4.0 Project Director
P19	Defense	Human Resources Business Partnership Leader	**P41**	Energy	Chief Information Officer (CIO)
P20	Medicine	Production Planning Manager			
P21	Steel	Chief Digital Officer (CDO)			
P22	Food	Research and Development Manager			

4. FINDINGS

Two main themes emerged from the interviews: the labor supply aspect and the Industry 4.0 aspect of skills mismatch. Below are the details about themes, categories, and codes.

Table 2. Themes, Categories, and Codes

Theme	Category	Code
Labor Supply Aspect of Skills Mismatch	Difficulties in Labor Supply	Skills shortage
		Skills gap
		Skills obsolescence
		Nature of the education system
	Difficulties in Retaining a Skilled Labor Force	Wages
		Labor turnover
		Working conditions
		Workplace location
		Lack of belonging
		Dissatisfaction
Industry 4.0 Aspect of Skills Mismatch	Labor Force's Adaptation to Industry 4.0	Transformation/Change rejection
		Technology acceptance level
		Different attitudes of generations in transformation
		Awareness
	The Emergence of Novel Business Models	Traditional ways of doing business
		Digital ways of doing business
		Lack of digital skills
		Upskilling employees

In the findings, we first interpreted the factors leading to skills mismatch and difficulties in retaining skilled labor force from the participants' perspectives. Next, we addressed skills mismatch

through the Industry 4.0 window and discussed the impacts of the labor force's adaptation to digital technologies on skills mismatch. Finally, we evaluated the effects of novel business models emerging with digital transformation on skills mismatch through the participants' views.

4.1. Labor Supply Aspect of Skills Mismatch

4.1.1. Difficulties in Labor Supply

As a result of the interviews, the participants stated that the companies are in the process of structural transformation due to developing digital technologies, automation and changes in labor market institutions. The most important challenge faced by the participants in this process is the inability to find the highly qualified workforce needed. On the other hand, the adoption of new technologies in practice may help boost productivity with the help of fresh business opportunities. However, new job types created in this process and the future of work can benefit society only with the availability of skills that can meet the demand for labor.

Skills mismatch showing up in companies both adversely affects labor force productivity and hinders the ability to introduce innovations and adopt new technologies. In this sense, skills mismatch due to Industry 4.0 practices is directly linked with the inability to provide a highly-skilled labor force, according to the participants. Challenges in matching supply and demand for skills in the labor market mean bearing various costs for companies since finding a suitable employee for a vacant position requires specific processes. In this context, the success of an appropriate match between supply and demand for skills depends on two factors: the efforts of both sides of the labor market and the relevance of job characteristics and employee profiles. On the other hand, the pace of technological advancements pushes organizations to be more flexible in adopting changes and making quick decisions. Thus, organizations may need to be more sensitive, agile, creative, and innovative. The digital revolution also makes it essential for businesses, governments, and individuals to anticipate trends and prepare for future skills needs. In a rapidly changing knowledge economy, 21st-century skills drive the competitiveness and innovative capacity of organizations.

The term "21st-century skills" has been coined to describe the type of labor force skills needed by companies newly adopting Industry 4.0 technologies. As mentioned, these skills are totally different from those required in the 20th century due to substantial changes in the business world. Over the past decade, many leaders and organizations, including the Partnership for 21st Century Skills (P21), have been exerting efforts to prepare today's graduates for a world of skills embodying critical thinking, communication, technology literacy, and collaboration (Greenhill, 2010:8). In this regard, P41 emphasized the importance of 21st century skills and stated that students now start their higher education journey almost without these skills. P17 and P2, on the other hand, highlighted the reasons for their companies to adopt Industry 4.0 practices and the importance of the acquisition of contemporary skills.

"Now, almost none of the students admitted to higher education have skills that we describe as 21st-century skills, such as critical thinking and problem-solving, creativity and innovation, collaboration, communication, information literacy, media literacy, information technology literacy, flexibility and adaptability, entrepreneurship and self-management, social and intercultural interaction, creativity and reliability, leadership, and responsibility." (P41, Energy Industry, İzmit)

"The acceleration of digital transformation will definitely cut costs, and we have to adopt this transformation. Unemployment will not increase in the long run since we are trying to contribute to the capacity and efficiency of our employees through exceptional training." (P17, Automotive Industry, İzmit)

"Indeed, technological transformation contributes to labor force transformation. Although our business is operated with manual jobs relying on physical strength, we may prefer our blue-collar employees to work smart rather than rely on their physical strength in this transformation. I think one's most prominent trait is feeling, which is the only trait that artificial intelligence cannot adopt. Therefore, there is a need for the transformation of the labor force (both blue-collar and white-collar employees)." (P2, Aluminum Industry, İstanbul).

21st-century skills cover social, emotional, and digital skills beyond technical knowledge and skills, known as "hard skills" (Koca, 2020). The participants attributed skills mismatch in the labor market primarily to a poorly functioning education system to satisfy the need for such skills. Accordingly, P1, P28, and P8 emphasized that students holding an undergraduate degree have limited practical knowledge, which was mainly attributed to insufficient internship programs and the ineffectiveness of university-industry collaborations. Therefore, it is recognized that it is critically important for students to learn how to integrate theoretical knowledge into practice in the workplace. In this context, the participants think that most of the newly graduated employees may need to undergo comprehensive training specific to the enterprise.

"It is nothing to do with higher education curricula, but the major problems often emerge when employees cannot discern how previously acquired knowledge is used or what it is for and how it can be turned into added value in the industry, society, and everyday life..." (P8, Furniture Industry, Kayseri)

"I should have learned statistics before engaging in working life. The statistics I learned at the university should have worked for me, but I have had to develop my statistical abilities with the Six Sigma Certification. All in all, university-industry collaboration programs need to be enhanced." (P1, Home Appliances Industry, İstanbul)

According to the participants, there is a growing concern that Industry 4.0 contributes to the university-industry mismatch that has been on the agenda for many years in Türkiye. Thus, it seems essential to set efficient university-industry collaborations to meet the need for new skills introduced by

Industry 4.0 practices. According to P11, poor university-industry partnerships in Türkiye may result from inconsistent education policies. While a few universities carry out such collaborations efficiently, the case is not satisfying in most universities.

"Collaborating with Sabanci University, we carry out a program for data analysis. While the program literally teaches what data mean to the participants, we work on where and how we utilize the big data." (P10, Tire Industry, Aksaray)

"I can propose that digital transformation has become a bit more requiring university-industry collaboration." (P7, Automotive Industry, Sakarya)

"The quality of education is gradually decreasing. Lack of a robust education policy and failure to establish effective university-industry collaborations... (Although a few universities carry out such collaborations efficiently, the majority mostly fail in this issue)." (P11, Tire Industry, Aksaray)

In general, skills mismatch ends up with two major consequences. First, the gap between supply and demand for skills often results in unemployment. Secondly, a poor company-employee match leads to decreased job satisfaction and productivity (Asai et al., 2020:24). Participants reported their inability to recruit a suitable labor force, particularly after launching Industry 4.0 technologies in the workplace. Most participants believe that higher education does not offer programs to teach the skills required by Industry 4.0 practices (P7, P30, P21).

"Recruiting the right employee is now rather challenging and creates substantial problems for us. Schools do not give graduates with desired competencies…" (P7, Automotive Industry, Sakarya)

"For example, we are in hard times hiring an employee to be hired in business intelligence since there is no such formal program in universities." (P30, Food Industry, Gaziantep)

The consequences of skills mismatch encompass all levels of the labor market and pose a significant problem for both highly-skilled and low-skilled labor. For example, the inability of individuals with high educational attainment to be hired in jobs that match their skills prevents them from demonstrating their productivity potential. On the other hand, being deprived of desired skills reduces one's chance of getting a job. The problem of skills mismatch brings adverse consequences on the productivity and competitiveness of businesses. Therefore, skills mismatch is a key factor in being able to introduce new products and services and adopt new technologies. In addition, the increased turnover due to skills mismatch even leads to profit and market losses for companies (ILO, 2020). One of the most important backgrounds of workforce skill mismatch is that it is very difficult to supply qualified workforce for digital technologies. In this context, P21, P11 and P30 emphasized that companies have difficulties in finding workforce suitable for digital transformation.

"No school teaches the competencies we are looking for. There is no school that offers programs for artificial intelligence and machine learning. Therefore, we can only transfer experienced staff and

acknowledge their market value. Such people either seek freelance projects or are employed in high-technology companies with incredibly high wages and do not prefer production companies. We generally train our staff and establish strong relations with universities through our R&D department." (P21, Steel Industry, Bursa)

"We cannot find the qualities and skills we seek in the new generations. Since children are not well-placed within the education system, the learning outcomes are not of good quality. These are huge societal problems." (P27, Defense Industry, Ankara)

"Yes, we have such a problem. The current education system does not serve today's needs and trends; thus, it needs to be updated to raise individuals who can adopt critical thinking, inquiry-based learning, and creative approach." (P40, Automotive Industry, İstanbul)

"It is nothing to engage in initiatives to establish smart factories without advanced engineering to utilize advanced technologies in such facilities, which becomes a prominent problem in Türkiye." (P11, Tire Industry, Aksaray)

"Given the socio-economic status of the overall population in our country, people often fail to make the right choices because they cannot manage their education, which makes us experience difficulties recruiting a suitable labor force. We need to make them unique to our business solutions. There are only a few of those who can meet our demands." (P30, Food Industry, Gaziantep)

P15, P1, and P7 pointed out the changes in the skills they expect from potential employees for Industry 4.0 technologies. For example, P15 stated that the company's human resources team is now more interested in the applications by process and R&D engineers. P1, on the other hand, reported that the transformation has started in the recent past and that they now prefer to hire those familiar with digital technologies. P7 stated that the company's need for problem-solving and software experts has increased with the digitalization of business practices, which may be considered an implication of Industry 4.0 technologies.

"We are well aware of the digital transformation in the job applications we receive because R&D and process engineers apply for our vacancies mostly. The transition is partly due to the necessity to ensure the supply-demand balance." (P15, Steel Industry, Istanbul)

"We intend to increase the number of our staff. Nevertheless, our business perception today is rather different from that of 3-4 years ago. We try to choose our colleagues among those with potent digital skills and competencies. On the other hand, it is related to the corporate culture, and our colleagues will even transform us." (P1, Home Appliances Industry, Istanbul)

"We are now on the eve of transformation and need colleagues familiar with machines. I mean we utilize automatic machines in welding more; thus, we need employees who know how to use and program these machines. We used to have hardware-related problems in the past, but now they are

about software, which means we need more software problem solvers." (P7, Automotive Industry, Sakarya)

We can claim that the supply and demand for skills are affected by many factors, such as demographic changes, migration, environmental changes, and - most apparently - advanced technologies. Technological changes underscore the need for one's continuous skills acquisition throughout working life. Employers, on the other hand, plan to mediate raising a labor force with digital skills and competencies to benefit more from this transformation. If deemed necessary, companies deploy their own trainers and leaders to enable the labor force to acquire the mentioned skills (Australian Industry Group, 2018).

Overall, these findings imply that companies experience significant skills shortages for Industry 4.0 practices. Skills shortages refer to a situation where supply cannot satisfy the demand in the highly-skilled labor market and are of particular concern to employers since being associated with productivity deficiencies (Haskel and Martin, 1993). The prominent indicator of skills shortages may be employers' inability to fill vacancies with skilled employees. To put it another way, skill shortages correspond to unfilled or hard-to-fill vacancies arising from a shortage of highly-skilled candidates for positions. Skills shortages are measured at the company level and usually cover a series of questions to identify unfilled or hard-to-fill vacancies and the employer's views on the underlying causes of any recruiting challenges. One difficulty in estimating skills shortages may be that some of the recruitment challenges attributed to skills shortages may actually be due to employers' inability to offer benefit packages or nurturing working conditions to attract relevant skills (CEDEFOP, 2015).

According to the research findings, one of the most striking factors is that young people do not prefer to work in the industrial sector. This situation causes companies operating in the manufacturing industry to not find the workforce with the skills they want. Instead, fresh graduates mostly prefer to work in the service industry instead of manufacturing companies. The participants pointed out the reasons why they prefer to work in the service sector as follows:

- The young do not favor working environments in the industrial sector,
- Compared to the service industry, they may perceive employment in the industrial sector as an indicator of low status,
- Insufficient social opportunities in the industrial sector,
- They may want to be promoted in a short time (vertical promotion),
- They usually have short and temporary goals for working life,
- They have high expectations from working life.

"Heavy industry is no longer favored in the labor market, and fresh graduates now tend to seek jobs where they can earn easier and more money. Therefore, the industrial sector, unfortunately, has a labor shortage. On the other hand, vocational schools are being closed nowadays since they cannot attract students anymore. Around 75% of our employees are vocational school graduates." (P15, Steel Industry, Istanbul)

"We are having great difficulties, particularly in recruiting blue-collars. Türkiye now experiences an unemployment problem, but the number of applications from skilled employees is rather limited when we open vacancies in our company." (P16, Steel Industry, Istanbul)

"New generation dreams earning more and easier and being promoted quickly.". (P17, Automotive Industry, Izmit)

"New generation dreams earning more and easier money and promoting quickly.". (P17, Automotive Industry, İzmit)

"New generation does not prefer to work in the heavy industry. For example, few METU and Bogazici graduates work in manufacturing industries. These industries host mostly employees being graduated from other universities. Moreover, they do not want to work in the factory but desire to be deployed in finance or sales departments in a plaza. In these industries, blue and white collars need to be in the factory when something unexpected happens at night, although they clock out at 18:00. I think there are not many to be able to accept such a working condition" (P2, Aluminum Industry, İstanbul)

"People who are used to working the way I mention are often high-profile employees. For example, we transferred our last employee from Google. Thus, we cannot deploy such an employee in our factory!" (P19, Defense Industry, Ankara)

While considering that "students do not prefer to work in manufacturing industries" as a major problem in the labor market, the participants also noted the inadequacy of vocational or technical schools to improve the skills of employee candidates. The findings implied that a potent solution mechanism to eliminate skills mismatch in the labor force graduated from vocational or technical schools may need to consider integrating vocational education into Industry 4.0, improving school-industry collaboration, updating formal curricula, increasing the quality of vocational schools, and expanding internship programs.

Implementing Industry 4.0 practices in the industrial sector inevitably raises concerns about supplying a highly-skilled labor force. Regarding how to raise the highly-skilled labor force through vocational education, the majority of the participants thought that students' learning experiences should be enhanced, improved educational models should be offered in vocational education, and students should acquire the ability to catch the latest developments related to their fields of interest.

Furthermore, most of the participants aired the following recommendations to improve vocational education in Türkiye:

- Raising students with skills demanded by the industrial sector,
- Enabling vocational schools to attract students,
- Improving the working conditions in the industrial sector,
- Initiating thematic redesigning of vocational schools by location and industry needs,
- Designing the formal curricula of vocational schools with the collaboration of the industrial sector,
- Ensuring that experts with substantial experience in the industrial sector teach some practice-related courses in vocational or technical schools,
- Promoting internship opportunities to contribute to students' learning experiences.

4.1.2. Difficulties in Retaining a Skilled Labor Force

Retaining a productive labor force may become the top priority for organizational success in today's business environment. Employee dissatisfaction may bring severe consequences for any organization, affecting employee turnover, service quality, productivity, and overall organizational success (Joarder et al., 2012). Hence, many organizations now invest significantly in their employees to develop their technical skills and competencies. It is deemed important to retain skilled employees since it may be more costly to replace them (Balamurugan, 2016). A study by the Technology Development Foundation of Türkiye (TTGV) (2020) showed that 81% of the industrial/real sector in Türkiye has difficulty in retaining highly-skilled human resources and that this rate is higher in multinational companies than in small and medium enterprises (SME). Logan (2000) pointed out the following key factors for employee retention: Communication, wages, flexible working models, organizational culture, and career development opportunities.

Healthy cultures lead to greater job satisfaction and boosted employee productivity in a high-production facility as well as more extended collaboration in company strategies. Strategy, operational efficiency, and tradition are strongly tied, and outperforming companies often see culture as a technical and production-related element and desire a culture as a way to help employees achieve pre-defined goals (Cherian et al., 2021:3). An apparent reason why companies have difficulties in retaining their labor force may be related to lack of belonging among employees. P36, P34, and P17 uttered their views on the lack of employee belonging as follows:

"One needs to have a sense of belonging. As long as a company has employees with robust time management and a sense of belonging, the rest can be compensated." (P36, Machinery Industry, Ankara)

"A greater sense of belonging will return higher benefits to the company. I think belonging is a precious personality trait." (P34, Defense Industry, Ankara)

"It depends, but I always hire those with a sense of belonging, high morality, self-confidence, and robust will." (P17, Automotive Industry, İzmit)

Employee behavior, principles, and beliefs affect not only productivity but also efficiency, and the nature of tasks and collaboration is of paramount significance to employees. Besides, employee turnover may have considerable impacts on the organization. For example, companies may need considerable time to recruit and train newbies as well as to promote their skills acquisition. In addition, employee turnover is always expensive due to the replacement costs of employees. The leave of an employee puts the assurance of talent at risk, and the company may need to spend significant money and time to select and train new employees (Lee et al., 2016), which adversely affects the company's operations in the long run. High turnover reduces the number of entry-level workers, mandates the use of temporary employees, ruins productivity and competitiveness, and hinders skills development (Al-Suraihi, 2021). The participants demonstrated the reasons for the higher turnover among younger employees as low wages and non-favored working environments. In addition, they emphasized a transfer market emerged for the highly-skilled labor force due to the increased turnover in the labor market.

"Employees with considerably-demanded skills and employed in critical positions enjoy the transfer market and are easily transferred from one company to another." (P40, Automotive Industry, İstanbul)

"I think manufacturing industries are literally under a serious threat. Therefore, we need to engage in an industry transformation to be able to make working environments more ergonomic, production-friendly, efficient, and preferable." (P15, Steel Industry, İstanbul)

A workplace environment can be defined with physical and behavioral components, and a widely accepted assumption is that a better workplace environment motivates employees and grants better outcomes. The design and layout of an organization's physical environment can affect employee behavior. Brill (1990) previously estimated that improvements in a workplace's physical structure can result in a 5-10% increase in employee productivity. Thus, granting adequate opportunities to employees may end up with greater employee engagement and productivity (Leblebici, 2012:39).

"Even physical conditions have been designed in accordance with the needs of our highly-skilled employees. To satisfy their needs, we have deployed our employees dealing with big data and machine learning work not in the factory but in a building designed as an open office and with more flexible working." (P19, Defense Industry, Ankara)

"For example, we cannot retain Bogazici and METU graduates for long; instead, we can retain the graduates of Kocaeli University, Sakarya University, and Istanbul Technical University." (P17, Automotive Industry, Izmit)

"I think wages are the most apparent reason why I have difficulty in retaining employees. Highly-skilled employees demand high wages and a better working environment. Sometimes, the industrial sector cannot respond to both their demands, a big issue in Türkiye. Both blue and white collars do not want to work in the industrial sector. Thus, companies need to pay more to attract them. Then, companies either lose their competitiveness in the case of wage rises or cannot retain their employees" (P35, Machinery Industry, Ankara)

"First off, highly-skilled employees need to feel secure both financially and legally in the company. Wages come second, and the way of working comes third. In this regard, overseas companies have a significant advantage in attracting highly-skilled employees." (P28, Food Industry, Gaziantep)

P19, P17, P35, and P28 associated the long-run retention of highly-skilled employees with better working conditions and wages. They also emphasized that highly-skilled employees do not prefer to work in the industrial sector since factories cannot provide a desirable working environment for such employees. The location of the companies is also one of the important variables in terms of labor supply. In this context, even in metropolitan cities such as Istanbul, Ankara and Izmir, the location of the companies determines the preferences of the workforce. Therefore, a significant part of the participants think that these locations should be made attractive for the workforce.

4.2. Industry 4.0 Aspect of Skills Mismatch

4.2.1. Labor Force's Adaptation to Industry 4.0

A key condition for adopting Industry 4.0 technologies in manufacturing industries may be the availability of highly-skilled human resources, which implies that the labor force should be able to adapt to digital technologies. Participants think that the workforce should be adapted to Industry 4.0 technologies. Moreover, they stated that many companies now aim to raise awareness among their employees through several informative activities. It has been observed that the work of companies in adapting their employees to Industry 4.0 technologies differs on a sectoral basis. It has been observed that companies operating in the automotive, white goods and pharmaceutical sectors attach more importance to the awareness of their employees.

"Employees are all aware that they are on the eve of an unprecedented transformation but cannot quite figure out how such a transformation will affect the industry and how the subsequent operations will be performed." (P20, Pharmaceutical Industry, İstanbul)

"Our employees have already started to be interested in big data, IoT, and automation. Many of them now attend training and seminars on these subjects." (P26, Automotive Industry, Ankara)

"The human resources department had an awareness of Industry 4.0 two years ago; thus, we launched projects and established project teams on Industry 4.0 with assistance from a consulting

company. We have attended training on the subject and attempted to train our employees." (P13, Automotive Industry, Ankara)

On the other hand, technology acceptance may differ between generations; accordingly, the participants emphasized the differences in technology acceptance between generations X, Y, and Z. Considering that the labor market is characterized by potential employees from different generations, it is then inevitable that every employee has a different level of technology acceptance. While P39 highlighted that learning capacity is directly proportional to age, P12 stated that generation Z may be more predisposed to adaptation to technological transformation than others. P5, on the other hand, pointed out that some employees resist digital transformation.

"Unfortunately, the capacity to learn new skills seems to decline with age." (P39, Pharmaceutical Industry, Istanbul)

"Generation Z will not sense a threat, but it seems to be the case for those around 40 years. Yet, they may need to feel the threat to be able to be intrinsically motivated and mobilized to take action against the possible threats." (P12, Automotive Industry, Ankara)

"As part of the digital transformation, the experts that our company has collaborated with held the very first training for our blue collars. Then, some reacted to the training, "I am only responsible for what my position requires in this company; it is not my concern!" Then, it is so clear that somebody will resist the change." (P5, Automotive Industry, Sakarya)

"They are well aware of the storm of a transformation but cannot quite figure out how such a transformation will affect the industry and how the subsequent operations will be performed. They have not much idea about what awaits the industry and how they will do this job in the future." (P20, Pharmaceutical Industry, İstanbul)

Technology acceptance is directly linked with to what extent one utilizes technology and is exposed to digitalization. Indeed, the tech-savvy youth may adopt technologies used in production easier than generations X and Y. In this sense, some participants stated that employees may resist technology use due to their "age."

4.2.2. The Emergence of Novel Business Models

The majority of the participants uttered that the way they do business is becoming changed and that novel business models have emerged as their companies have started to adopt Industry 4.0 technologies. For them, novel business models are most visible in manual and repetitive jobs. Accordingly, the replacement of jobs not requiring robust qualifications with machines or robots has led to the emergence of new highly-skilled jobs. P20 showed digitalization as the most apparent indicator of changes in business models. He stated that high school graduates used to be engaged in only

mechanical jobs. P39, on the other hand, emphasized that the way of doing business is getting changed among blue collars since they are now expected to respond to devices when necessary.

> *"We used to recruit employees who were primarily high school graduates, and they were more engaged in mechanical jobs. Today, machines are able to collect and process data." (K20, Pharmaceutical Industry, Istanbul).*

> *"We have started to experience the Industry 4.0 change since even the equipment operated by blue collars is now more connected and complex. Blue collars have to respond to, troubleshoot, and monitor the problems of state-of-the-art devices." (K39, Pharmaceutical Industry, İstanbul).*

According to Arntz et al. (2019), automation processes used with Industry 4.0 point to three basic elements in terms of job losses or reduction in employment. The first is the gap between the potential and actuality of technology, the second is the potential of technological development to create new jobs, and the third is the ability of employees to adjust their skills to new technologies. Undoubtedly, the business world is experiencing a transition from traditional ways to digital ways of doing business thanks to technology integration into existing production processes. To make this process sustainable, the labor force then needs to acquire new skills demanded by digital business/novel business models. Most of the participants thought that the emergence of novel business models affects the job definitions of both blue and white collars. For them, routine and repetitive jobs, manual dexterity-demanding jobs, and jobs posing risks for employees have started to be digitalized (P24, P30, and P21).

> *"Manual dexterity used to be appreciated much in the past, but machines have now been deployed in the processes in the further processing stages in our factory." (P24, Food Industry, İzmir)*

> *"The production line is now completely robotized. For example, a fully automatic line performs cooling, packaging, boxing, and barcoding the products and sending them to our smart warehouse." (P30, Food Industry, Gaziantep).*

> *"Our priority is safety, namely occupational health and safety. It is invaluable to us to be able to prevent an accident thanks to new technologies." (P21, Steel Industry, Bursa)*

A striking finding of our research was the attribution of skills mismatch to Industry 4.0 practices. Accordingly, a significant part of the participants emphasized that it is now essential to ensure employees' adaptation to Industry 4.0 technologies, which is directly linked with accelerating the transition from traditional to digital business models. Therefore, employees' skills acquisition is the hot agenda of companies in the manufacturing industries since the deployment of machines for routine and repetitive jobs requires the reallocation of employees in other areas. In other words, the available skills of the labor force reallocated in other areas become obsolete, forcing them to acquire new skills.

5. CONCLUSION

Industry 4.0 seems to have brought different impacts on the industrial sector. This is not only related to the use of technologies in production, but also directly related to workforce skills. Thus, it is not prudent to consider Industry 4.0 practices to be a driving force for extending production models with technology since the smooth utilization and management of technology in the manufacturing industries highly relies on highly-skilled human resources. Qualified workforce creates a competitive advantage for companies on a global scale and ensures the sustainability of the Industry 4.0 process. However, one of the biggest problems faced by companies in this process is skill mismatch.

Current theoretical debates on the causes of and relevant policy focuses on skills mismatch are often based on two approaches. The first attributes skills mismatch to the supply side comprising governments, education institutions, and individuals. This supply-side approach, grounded on human capital theory, explains the emergence of market failures and skills mismatch that hinder the skill supply from responding to employers' demand for skills. The second, on the other hand, attributes skills mismatch not only to the supply side but also to the demand side, focusing on employers' demand and skills use.

In this study, the reasons for skills mismatch in Turkish manufacturing companies during the transition to Industry 4.0 were grouped under four main categories: difficulties in labor supply, difficulties in retaining the labor force, employees' technology acceptance, and the emergence of novel business models. What primarily leads companies to experience significant challenges in labor supply is that the young labor force no longer prefers to be employed in the industrial sector for the following reasons: the industrial sector's inability to attract the young labor force, not flexible and ergonomic working conditions in the sector, and their perception of low status when being employed in this sector. The participants showed low wages and poor career development opportunities as the major reasons why the industrial sector cannot become attractive to the young labor force.

The participants thought that models and programs in both higher education and vocational or technical schools have become obsolete in raising human resources with skills satisfying employers' demands and needs, the underlying reason why today's business world cannot hire a labor force with desirable skills. Thus, the education system and curricula need to be revisited so that the labor force - considered a key pillar of digital transformation - can acquire new skills. Another reason for the gap between skills supply and demand stems from the difficulties in retaining the labor force, according to the participants, which is affected by wages, employee turnover, poor working conditions for highly-skilled human resources, a loose sense of belonging, and company location.

Employees' technology acceptance is another factor in matching supply and demand for skills. Technology acceptance is directly linked with how much one uses technology in daily life and is exposed to digitalization. Indeed, the tech-savvy youth may adopt technologies used in production easier than

generations X and Y. In this sense, some participants stated that employees may resist the use of technology due to their "age."

The participants emphasized another factor predicted to trigger skills mismatch to be novel business models emerging with changes in the ways of doing business. To put it another way, the transition from traditional to digital ways of doing business seems to make change inevitable for both blue and white collars. Widespread adoption of Industry 4.0 practices in production mandates routine and repetitive jobs to be handled by machines, making it necessary to reallocate the labor force to the other areas of production processes. Moreover, it becomes imperative that the reallocated labor force should acquire new skills.

The integration of Industry 4.0 technologies into production processes raises the problem of lack of highly skilled workforce. This situation, described as a skills shortage in the literature, refers to the inability to satisfy the demand for highly qualified human resources and then triggers the skills mismatch. Undoubtedly, the primary solution for the gap between supply and demand for skills seems to adapt the formal and informal curricula to the contemporary requirements of the business world. In this sense, the majority of the participants mentioned the lack of a higher education program offering the necessary skills for white collars. Another problem is the inequality of quality in educational institutions. The participants confessed that they prefer to hire those graduating from the top ten universities in Türkiye.

An important way to facilitate skills acquisition for blue and white collar workers may be to enhance their learning experience. In this regard, the participants found internship experiences offered to the young labor force insufficient and stated that poor internship practices reduce students' motivation and the effectiveness of the internship period.

We can propose that robust collaborations between the business world and education institutions will balance the supply and demand for skills. Improving the sensitivity and responsiveness of the education system to the needs of the labor market can facilitate the employment of the young in the industrial sector. At this point, the increasing demand for digital skills is so important that it cannot be ignored. The machines used by many large-scale manufacturing companies in production make the use of basic and upper digital skills essential. The most important factor at this point is the necessity of strengthening the continuous learning mechanism. As a matter of fact, the high level of skill that individuals have will make it easier for them to acquire new skills.

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