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State of progress of industry 4.0 in the maquiladora: effects on employment in Mexicali, Mexico

Estado de avance de la industria 4.0 en la maquiladora: efectos en el empleo en Mexicali, México

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ABSTRACT

The maquiladora industry in Mexico especially in the north of the country represents an important source of employment and social security, therefore, this article addresses the question of what would happen if new technologies displaced workforce in this economical sector? The objective of this research is to determine the maturity level of Industry 4.0 in the electronic maquiladora of Mexicali, in Baja California and its possible repercussions on the employment for operators and engineers. To understand and know the nature of this phenomenon, a case study was carried out on five of the most important companies in the region, the methodology used was quantitative and qualitative. Three surveys were designed based on the research of the Sectorial Model Reference Industry 4.0 made by the Valencian Institute of Business Competitiveness (IVACE) and the European Regional Development Fund and were applied to engineers in the department of investigation and development, operators, and to a Human Resources worker. In this regard was designed an interview that was applied to a key expert that gave us the point of view about the actual status of the developing of the industry 4.0 in the city of Mexicali. The overall conclusion is that the state of advancement of Industry 4.0 in the electronic maquiladora in Mexicali has an intermediate digital maturity (level 2-3), that is, in many cases the technology is known and used, but only by specific processes. Regarding the digital skills of engineers, it was found that they are highly trained to face the challenges of the new digital era, while the operator positions report a level of digital competence between low and medium, which places this profile of worker in a vulnerable situation for keep their position.

Keywords
Industry 4.0; electronic maquiladora; technological unemployment; new technologies; digital skills

RESUMEN

La industria maquiladora en México, y sobre todo en la zona norte del país, representa una fuente importante de empleo y seguridad social; sin embargo, ¿qué pasaría si las nuevas tecnologías desplazaran a los trabajadores de este sector? El presente trabajo tiene por objetivo determinar el estado de incorporación de la industria 4.0 en el sector maquilador electrónico de Mexicali, en Baja California, y sus posibles repercusiones en el empleo de los operadores e ingenieros de producción. Con el fin de entender y conocer la naturaleza de este fenómeno, se realizó estudio de caso a cinco de las empresas más importantes de la región. La metodología utilizada fue cuantitativa y cualitativa, para lo cual se diseñaron tres encuestas basadas en el Modelo Sectorial de Referencia Industria 4.0, realizado por el Instituto Valenciano de Competitividad Empresarial (IVACE) y el Fondo Europeo de Desarrollo Regional, las cuales se aplicaron a un representante del departamento de Investigación y Desarrollo, a un ingeniero, a un operador y a un representante de recursos humanos. Para anticipar la naturaleza de este fenómeno, se estructuró una entrevista dirigida a expertos clave. La conclusión es que el estado de avance de la industria 4.0 en el subsector de la maquiladora electrónica en Mexicali tiene una madurez digital intermedia (nivel 2-3), es decir, en muchos casos se conoce y utiliza la tecnología, pero solo en determinados procesos. En relación con las habilidades digitales de los ingenieros, se encontró que están altamente capacitados para enfrentar los retos de la nueva era digital, mientras que los puestos de operador reportan un nivel de competencia digital entre bajo y medio, lo cual ubica a este perfil en una situación vulnerable para la sostenibilidad de este tipo de puestos.

Palabras clave
Industria 4.0; maquiladora electrónica; desempleo tecnológico; nuevas tecnologías; habilidades digitales

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Introduction

There are discrepancies regarding studies on the fourth industrial revolution, also called industry 4.0, and its effects on employment; however, it is a fact that the digital transformation heralds a disruption in the way of working in society, especially in manufacturing jobs, where simple execution activities are regularly developed and low-skilled workers are required (Wilson, 2018); therefore, new technologies represent a great challenge in the socioeconomic development of each country.

When talking about industry 4.0, it refers to the use of disruptive technology; that is, one that with its innovation creates a new socioeconomic ecosystem. This technology can be divided into physical and virtual. The former refers to robots, automated machines and additive technology, while the latter is all technology that is not tangible, such as the internet of things, virtual reality, big data, the cloud, virtual simulation, cybersecurity, augmented reality and artificial intelligence.

In the case of Mexico, in matters of employment and economic growth, in the last fifty years, efforts have been related to wage containment in the maquiladora industry, thus creating low-competition jobs (Fariza, 2017). With the arrival of the new government in 2018, a significant increase in citizens' wages was approved, especially in the northern border; however, the monetary adjustment has not compensated for the loss of purchasing power that has existed in recent decades.[1]

In the state of Baja California, the maquiladora industry represents an important source in the economy, with Mexicali being the municipality with the second highest concentration of establishments dedicated to the manufacture and assembly of electrical and electronic devices, which has allowed the creation of almost 35 000 jobs (Secretaría de Economía, 2017). The Covid-19 pandemic has generated important changes in the use of technology in the manufacturing industry. For example, the National Chamber of the Electronics Industry of Telecommunications and Information Technologies (CANIETI, 2019) is in the process of designing a digital economic agenda to accelerate the implementation of Industry 4.0, with the purpose of facing the challenges posed by the pandemic and the continuity of the industry's work.

The purpose of this paper is to analyze the adoption of virtual and physical technologies, called Industry 4.0, and their effects on the employment of workers in the Maquiladora and Manufacturing Export Industry (IMMEX, by its acronym in Spanish), engaged in electronics in the municipality of Mexicali, Baja California, Mexico. To carry out this study, the five most representative, dynamic and successful maquiladoras in the city in terms of employment generation and economic growth were identified.

This study is an exploratory work, given the scarcity of literature on the subject. The questions that guided the research were: what is the level of digital maturity of the electronic

maquiladoras in Mexicali, how does this level contribute to the creation or reduction of jobs, and what is the level of technological and digital skills of the personnel (engineers and operators) to face the new requirements of Industry 4.0?

This research began by considering that the level of digital maturity of the maquiladora electronics industry in Mexicali is intermediate, i.e., all technologies are known, but have rarely or never been implemented. It was also based on the assumption that engineers have high digital skills and, on the contrary, for operators these skills are either low or nonexistent.

The article is divided into four sections. The first section discusses Industry 4.0 and the fourth industrial revolution as a frame of reference, as well as its relationship with the concept of digital maturity. The second section refers to the relationship between Industry 4.0 and employment, while the third section explains the background of the electronic maquiladora in the region. Finally, the last part analyzes the findings in the five case studies on the maquiladora industry of the electronics sector in Mexicali.

Industry 4.0 and the fourth industrial revolution

In literature, when the current technological era is mentioned, allusion is made to both Industry 4.0 and the fourth industrial revolution, and although both concepts are part of the same process, it is necessary to differentiate their nuances. The first is related to the use of new IT technologies to implement the internet of things in service, as a means to create a more flexible, efficient and cleaner production, with higher quality at a lower price (Wan *et al*., cited in Emil, 2017; Liao *et al*., 2017); that is, industry 4.0 refers to a set of intelligent technologies created to change the way of manufacturing and marketing.

The fourth industrial revolution is a concept related to a radical socioeconomic change, which is considered a predecessor of the industrial revolutions that have arisen in the last 200 years (Liao *et al*., 2017; Schwab, 2016). This term describes a new era of technological, innovative and disruptive transformations that bring about changes in the economic, social and environmental structure of civilization.

From a business perspective, Industry 4.0 pursues the fundamental objective of increasing efficiency in its value chains to obtain above-average yields; therefore, entrepreneurs seek to improve all their processes to achieve more competent results, which implies a reduction in the workforce. In short, Industry 4.0 is the union of non-tangible technology with physical technology, with the purpose of being able to self-manage and adapt to market demands (National Institute of Standards and Technology, cited in Emil, 2017; Liao *et al*., 2017; Gera & Singh, 2019).

Business digital transformation is the next evolution for this sector. Because of this, consulting firms and industrial researchers are focused on designing an instrument that allows them to assess the level of utilization, as well as the state of incorporation of each of the technologies, called maturity level or digital maturity. But what is the purpose of knowing how much technology a company uses? Studies conducted by companies such as McKinsey point out that companies that incorporate digitization strategies into their processes will differentiate themselves from companies that do not use them (Baughin *et al*., 2017). For this reason, it is important for entrepreneurs to obtain a diagnosis of the degree of use of innovative tools that will allow them to implement the best strategies for a successful digital transformation.

Likewise, there is the Digital Maturity Model presented by the Valencia Institute for Business Competitiveness (IVACE, 2016), in coordination with the European Union and the European Regional Development Fund, which was designed based on information from several existing maturity models. IVACE (2016) groups technologies and divides the Industry 4.0 model into four areas: technologies that give the company the degree of total hybridization from the physical to the digital world, business-consumer connection technologies, communication and information processing technologies and, finally, business management technologies, which analyze their level of incorporation.

Digital maturity is the combination of digital technologies and operational changes that allows companies to comprehensively transform the way their value chain operates, i.e., to use scientific advances such as artificial intelligence, robotics or the internet of things to improve operating results and obtain higher-than-average returns.

The future of employment in the face of Industry 4.0

4.0 technologies are tools that will undoubtedly transform workers' practices, including employment. Some authors such as Minian and Martinez (2018), as well as Gera and Singh (2019), mention that this change will eliminate some jobs and, likewise, create others; however, Wilson (2018) mentions that the digital change will be so fast that the displacement of man by machine will exceed the creation of new jobs, which will generate a labor deficit. Furthermore, David Ricardo (cited in Gera & Singh, 2019) assures that an increase in productivity needs new technologies that can hardly be matched in relation to a highly trained employee, therefore, the displacement of man by machine for the economic and social development of a nation is a fact.

One of the most recent studies on the effects of new technologies on employment is that carried out by Frey and Osborne, who state that 47% of jobs could disappear in less than twenty years. An example of this displacement is the automated drivers of the near future, a project promoted by Uber,[2] where supposedly a driver will not be required, but

the computer will do the job of driving the vehicle. This technology is expected to replace 20% of the jobs in this sector in the United States (Wilson, 2018; Gera & Singh, 2019).

The above arguments evidence the challenge that new technologies represent for the development plans of current governments, mainly on the issue of job creation. Mexico presents deficiencies and lags in the development of human capital, since only 18.6% of the population over fifteen years of age has higher education, 21.7% has higher secondary education, 23.7% has secondary education, 15% has primary education and 5.8% has no education (INEGI, 2015).

In this context, the educational characteristics of the country's manufacturing sector are no better. According to a study by the National Institute of Statistics and Geography (INEGI, by its acronym in Spanish) (2011) on the skills of manufacturing workers in Mexico, conducted in 2008, evidenced that of the 4.5 million workers, 2% do not know how to read or write, 16% have primary education, 36% have secondary education, 14% have high school, 11% have a technical career and only 14% have professional studies.

In 2017, the World Economic Forum (WEF) conducted an analysis of the skills of workers worldwide to compare the degree of competitiveness between the human capital of different countries. Mexico is in the 69th position in the ranking of the 130 countries evaluated, where, the higher the position of the nation, its evaluation in terms of education, skills, development and knowledge is more unfavorable. Therefore, Mexico does not represent a competition against countries such as Norway, Finland, Switzerland, the United States, Denmark and Germany, which occupy the first six places of the nations with the best human capital development (WEF, 2017).

This problem can be based on the national development plans of the last fifty years, aimed at exploiting economic labor in order to obtain foreign investment; however, these development policies have ceased to be effective, due to the fact that technology is displacing those jobs that are simple, repetitive and executed by low-skilled human capital (Fariza, 2017). In the words of the WEF, “today's developing economies are still basing their economic growth on cheap labor alone, but the jobs and sectors driving these trends risk leaving a growing share of the force” (2017, p. 4).

The jobs most at risk of facing the impact of Industry 4.0 are likely to be in the manufacturing sector at the blue-collar level, due to the fact that tasks are often routine and can be easily programmed through an automaton skill algorithm. McKinsey (2017, cited in Schatan, 2018) stated that 64% of productive activities in the manufacturing sector are highly automatable, so 4.9 million employees are at risk of losing their jobs.

Due to rapid technological advancement, it is difficult to keep up to date and, according to Wilkins (2018) and Gera and Singh (2019), it is even more complicated in the electronics sector, where the most high-tech components are manufactured. Because of the

above, without constant investment in state-of-the-art machines and equipment, there is a risk of remaining in obsolescence. The possibility of a digital transformation in the electronics sector is inevitable, because scientific advances are the key to competitiveness in the market. According to Villa (2020), the current Covid-19 contingency has accelerated this change, because entrepreneurs perceive the need to keep the manufacturing sector updated under any circumstances.

The National Chamber of Electronics Industry of Telecommunications and Information Technologies (CANIETI, by its acronym in Spanish) northwest, promotes the incorporation of Industry 4.0. According to its president, Román Caso, "some companies in the region are already able to continue producing at the same levels with a smaller number of workers" (quoted in Villa, 2020, n.p.).

The maquiladora electronics industry in Mexicali

Mexico's industrial development has had a close relationship with the urbanization processes of the northern border and the challenges it faces (Tamayo, 1992; Barraza, 2020; Galván and García, 2018). In 1935, Mexicali and Tecate were designated as free perimeters, with the right to import goods from abroad without payment of tariffs, which was the first step for the industrialization of the border zone (Douglas & Hansen, 2003).

In 1942, the Mexican government achieved the first International Migrant Workers Agreement, created to support the United States with labor for the agricultural fields and to replace Americans who were in combat in World War II (Barraza, 2020). Twenty years later, the U.S. government decided to cancel this agreement, which caused about 50% of the population in border cities, such as Mexicali and Tijuana, to lose their jobs (Douglas & Hansen, 2003; Galván & García, 2018).

In 1965, the Mexican government created the Border Industrialization Program (PIF) as a response to the problems of employment shortages and poverty by following trends in foreign manufacturing, wage increases, and technological advances in industrialized countries (Tamayo, 1992; Dorocki & Brzegowy, 2014; Carrillo & Hualde, cited in Galván & García, 2018). By the end of 1967, the PIF had 57 maquiladoras and 4 257 employees in Matamoros, Nuevo Laredo, Ciudad Juárez, Mexicali and Tijuana (Douglas & Hansen, 2003; Dorocki & Brzegowy, 2014). By the end of the 1960s, Mexico had 147 maquilas and about 17 000 employees, and ranked third among exporters of products to the United States with tariff item 807.00[3] (Douglas & Hansen, 2003).

Currently, the Maquiladora and Manufacturing Export Industry (IMMEX, by its acronym in Spanish) has a very important place in the Mexican economy, since, according to INEGI, in 2019 it obtained 300 billion dollars from exports (INEGI, 2019). In this industry, one of the most important sectors at national and international level is electronics, due to the

fact that it represents an important source of jobs. In Mexico, this is mainly located in the northern border strip, and the state of Baja California is the leader in number of companies, with 184 factories. Similarly, Mexicali is the municipality with the second highest concentration of the sector, with 22% of the establishments, which employ almost 35 000 workers (Secretaría de Economía, 2017).

Most of the products manufactured in the country's electronic maquiladora industry are of intermediate technological level, that is, the technical complexity and degree of technological maturity require a medium degree of technical knowledge (Secretaría de Economía, 2017). In the case of the degree of digital maturity of production processes, the industry in this sector registers a low standard level, since it is characterized by manual assembly, packaging and transfer operations (Secretaría de Economía, 2017).

Methodological strategy

The research strategy followed in this study was an exploratory case study of five companies in the municipality of Mexicali, Baja California, which manufacture computer, communication, measurement, and electronic components and accessories equipment. The selection criteria were: 1) having more than 100 employees; 2) being highly recognized companies worldwide; 3) manufacturing high-tech products; and 4) having been established in the city of Mexicali, Baja California, Mexico for more than fifteen years.

The methodology of this research has a mixed approach, that is, both qualitative and quantitative, due to the fact that three virtual questionnaires were designed and applied to the five companies: a digital maturity survey, a survey of employees' digital skills and hiring trends in the labor market in the maquiladora industry in the region that were conducted between the months of August and November 2020. At the same time, interviews with key experts were used in November 2019.

For the design and structuring of the surveys of the level of digital maturity and digital skills of workers, information from the Industry 4.0 Reference Model proposed by IVACE (2016) was used. The digital maturity survey was applied to engineers from research and development departments within the companies, with the objective of analyzing: 1) the transformation from physical to digital, 2) digital communication and data management, and 3) internal management of the company.

Digital transformation is the set of technologies that enable the shift from the tangible to the virtual world. The communication and management of digital data are evidence of a technological ecosystem that transforms the way of working through tools such as big data, the internet of things and the cloud, hand in hand with technologies such as cybersecurity. Digital business management systems are a scientific breakthrough from the 1960s that has evolved into what is known as Enterprise Requirement Production (ERP).

These are all those programs that take care of operations within a company, from production, distribution, human resources, shipping and warehousing. These systems represent an advantage for the industries that apply them; however, there are companies in which management is still done manually by workers.

The second survey was applied to engineers and operators, and the following aspects were considered: 1) digital skills for handling and managing virtual information, 2) management skills and physical use of available technological instruments, and 3) administrative and business management skills. As with the level of digital maturity, the four degrees of knowledge and use of technologies were also considered for the skills (the higher the degree, the greater the knowledge).

In addition, a questionnaire aimed at human resources departments was applied, designed based on the information obtained from the research proposed by the General Union of Workers of Castilla y León (2017) on Industry 4.0. The objective of this survey was to evaluate the hiring trends of the last five years, as well as to obtain information on training, new skills and knowledge required due to technological changes in the new digital era. Table 1 shows the companies surveyed and the main activity they perform.

Table 1. Business activities

Company	Main activity
Sensata Technologies Mexicali	Manufacture of electronic sensors for the automotive and heavy vehicle industry
Skyworks Solutions de México, S. de R.L. de C.V.	Development of semiconductors used in the medical, military and telecommunications industries
Robert Bosch Tool de México, S.A. de C.V.	Assembly of power and cordless tools
Tecnomex Industrial, S.A. de C.V.	Repair of electronic equipment
Furukawa México, S.A de C.V.	Manufacture of electronic parts for the automotive industry

Finally, a semi-structured interview was designed, addressed to experts from the private sector, in order to inquire about the trends and evolution of the implementation of Industry 4.0 in the manufacturing sector and its possible impacts on employment. The key informants represented the approach as seen from the practices of an educational institution, a business organization and a cluster company.

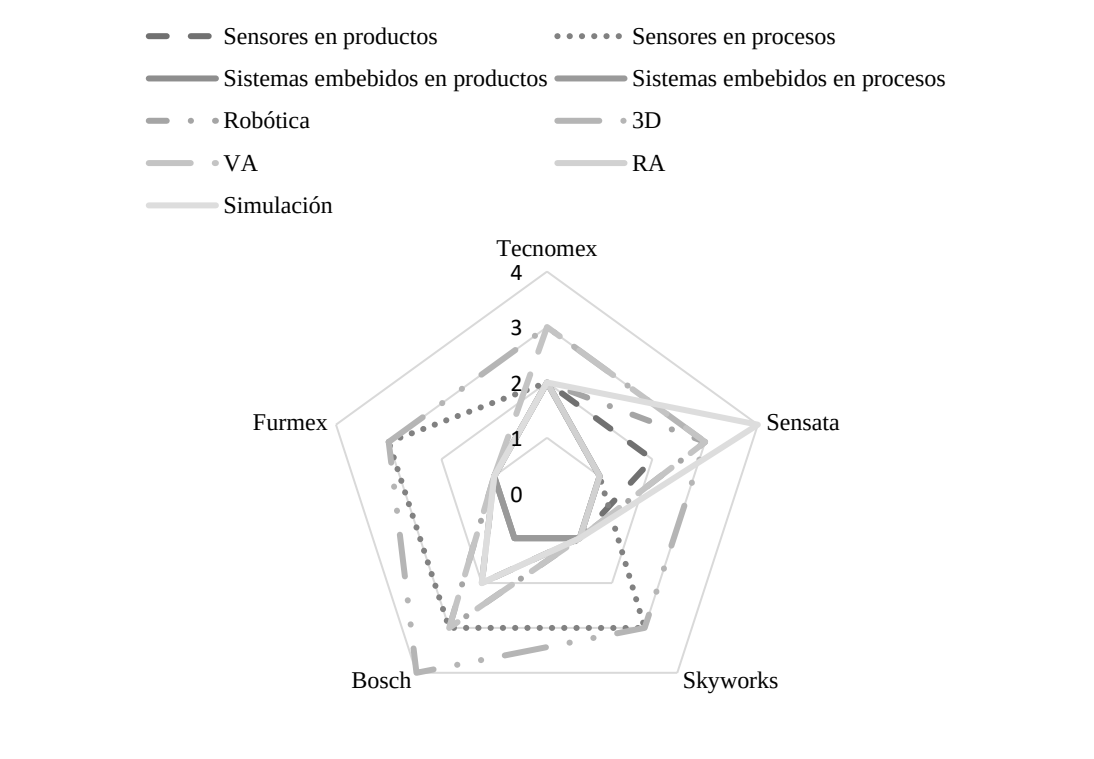
Results

Transition from physical to digital

As a result of the assessment of the physical to digital transformation of the companies under study, it was found that, of the five companies, four are at a digital maturity level of 2 to 3 in the use of these technologies, which indicates that the company has knowledge of the technology, but does not use it in small pilot run projects (see figure 1). However, additive technology is a tool that has been rapidly incorporated into the production processes of several companies.

Similarly, Sensata Technologies reported a maturity level of 3 to 4 in most of the technologies (see figure 1), i.e., the company has an in-depth knowledge of the technology and implements it in its value chain. Due to the products it manufactures, the company requires a high level of innovation, as well as a high degree of digital maturity

Figure 1. Transition from physical to digital

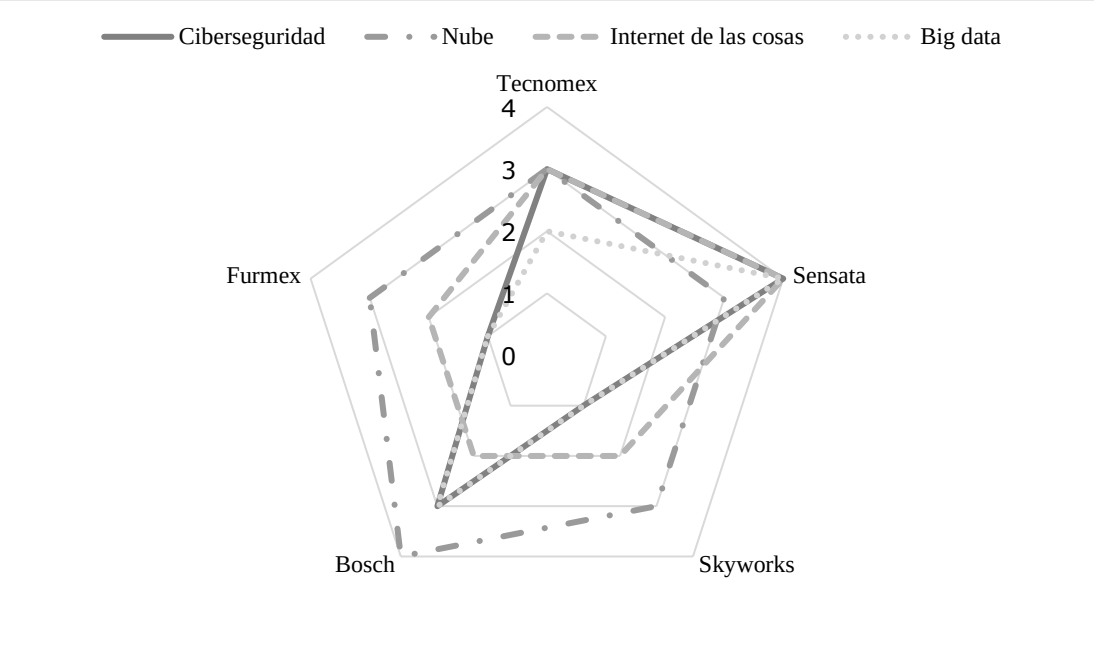


Source: developed by the author, based on interviews with those responsible for engineering.

Incorporation of information technology tools. Digital data management

Regarding the degree of incorporation of these technological tools, it was identified that the companies Tecnomex, Skyworks, Furukawa and Bosch have a digital maturity level of 2 to 3, that is, the degree of use and knowledge ranges between 25% and 75% of understanding and use, depending on the technology. On the other hand, Sensata reported a level of utilization of its technology from 3 to 4, i.e., its transition to Industry 4.0 in this area of technology is almost complete (see figure 2). As in digital transformation, in virtual data management systems, most companies were identified as having an intermediate level of digital maturity.

Figure 2. Communication for the management of digital data



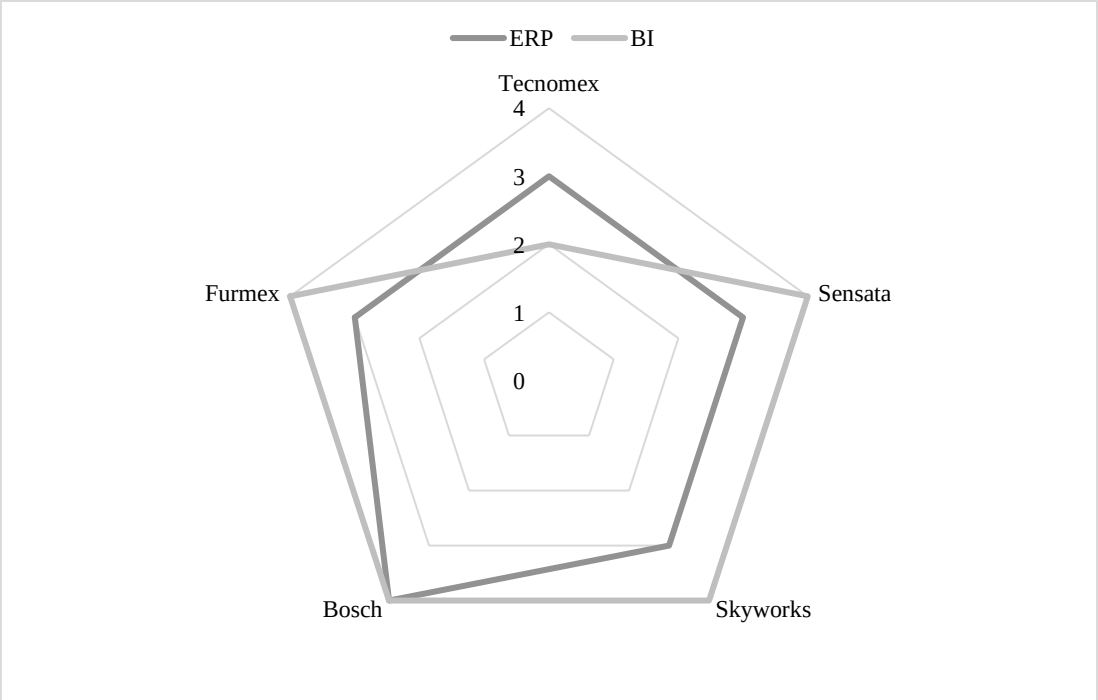
Source: developed by the author, based on interviews with those responsible for engineering.

Digital business management

The company Bosch has a maturity level of 4 in ERP technology, which indicates that the implementation of management and logistics programs in this company is high. On the other hand, Tecnomex, Sensata, Skyworks and Furukawa report a level of 3, which reflects that they have knowledge of the technology and use it, but not completely.

Regarding intelligent business software (BI), most companies report a maturity level of 4, as they process digital information through this technology in a generalized way (see figure 3).

Figure 3. Digital business management



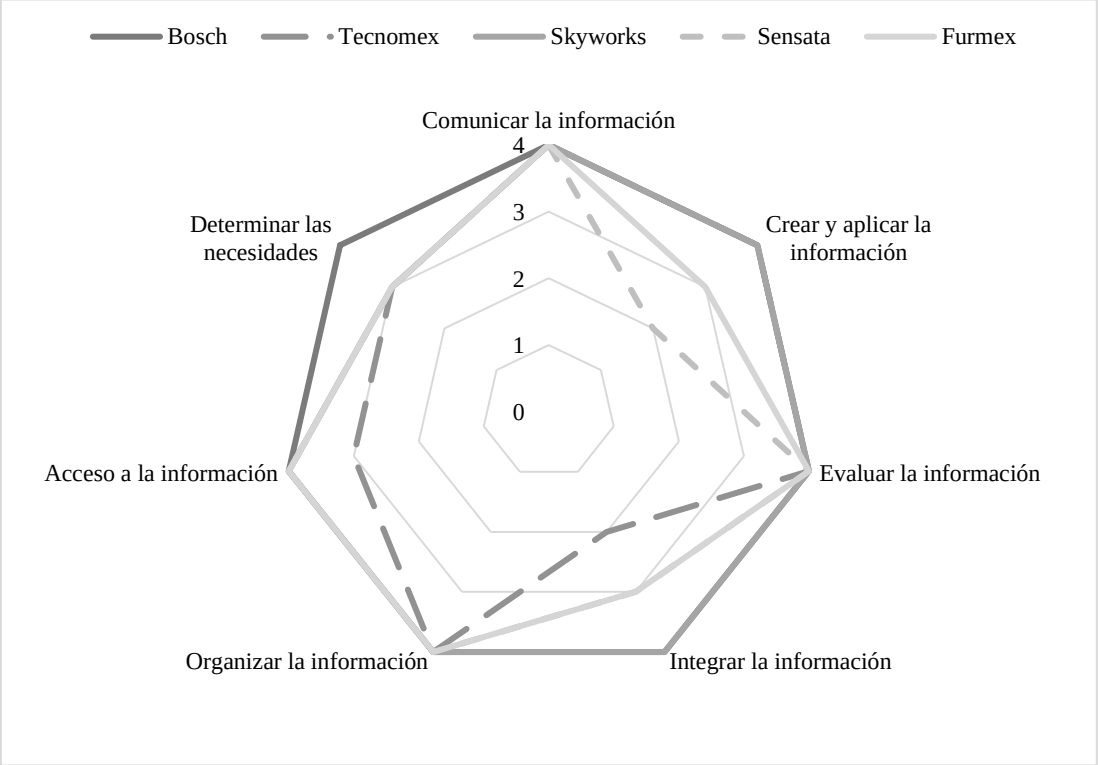
Source: developed by the author, based on interviews with those responsible for engineering.

Digital skills of the worker facing the new requirements of industry 4.0. Engineering position

Digital information processing

The success of the digital transformation is based on highly technical positions, such as engineers, due to the knowledge, skills and advanced techniques they use to continuously improve production processes. It was found that, for engineering positions, the workers of the five companies are highly skilled; a level of 3 to 4 is reported, that is, they have knowledge and skills to use information processing technology in a capable way (see figure 4).

Figure 4. Processing of digital information

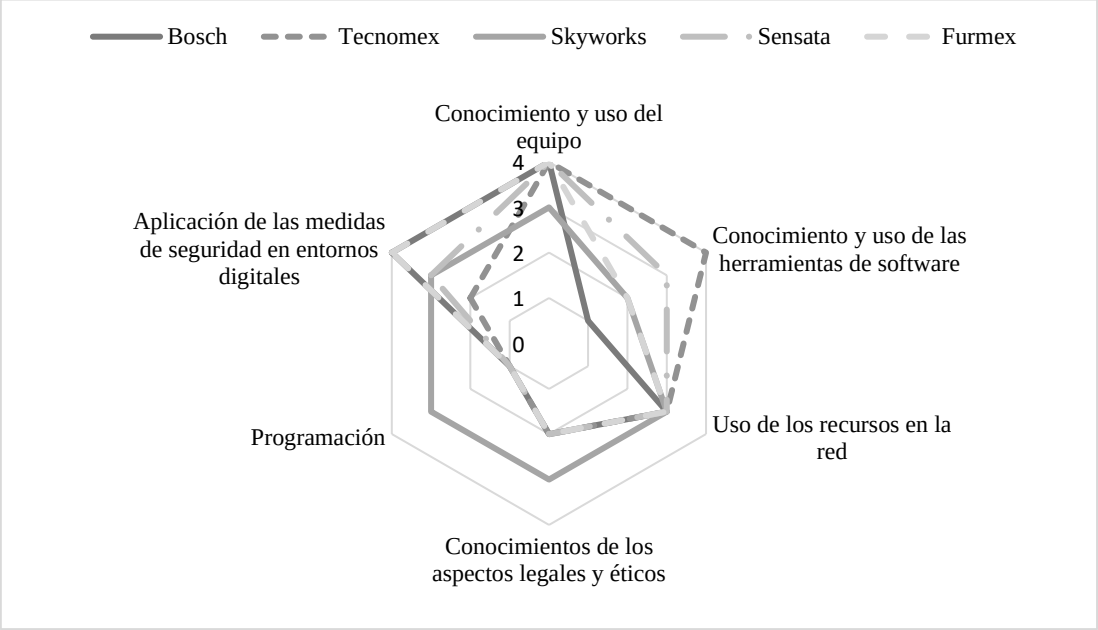


Source: developed by the author, based on interviews with those responsible for engineering.

Skills in the use of digital tools

It was identified that there is a delay in the knowledge of programming. Of the five companies, four report having zero skills, and only one has a level of 3. This technological tool is of utmost importance for labor competitiveness and digital transformation, since it is the language used to communicate with machines so that, in turn, they can execute the required orders. Regarding the rest of the skills in the use of digital tools, it was found that engineers present a knowledge level of 3 to 4, which means that they know the technology and apply it, in some cases in a timely manner and in others continuously (see figure 5).

Figure 5. Skills for using digital tools



Source: developed by the author, based on interviews with those responsible for engineering.

Personal competencies

In the case study, in the engineering positions, it was observed that personal competencies such as self-learning, organization and planning, continuous improvement and teamwork are highly developed in the engineers of the five companies, since they reported, on average, a degree of competence of 3 to 4, which may be due to the fact that, for the most part, they are workers who have bachelor's or master's degrees.

Digital skills of workers facing the new requirements of Industry 4.0. Operator position

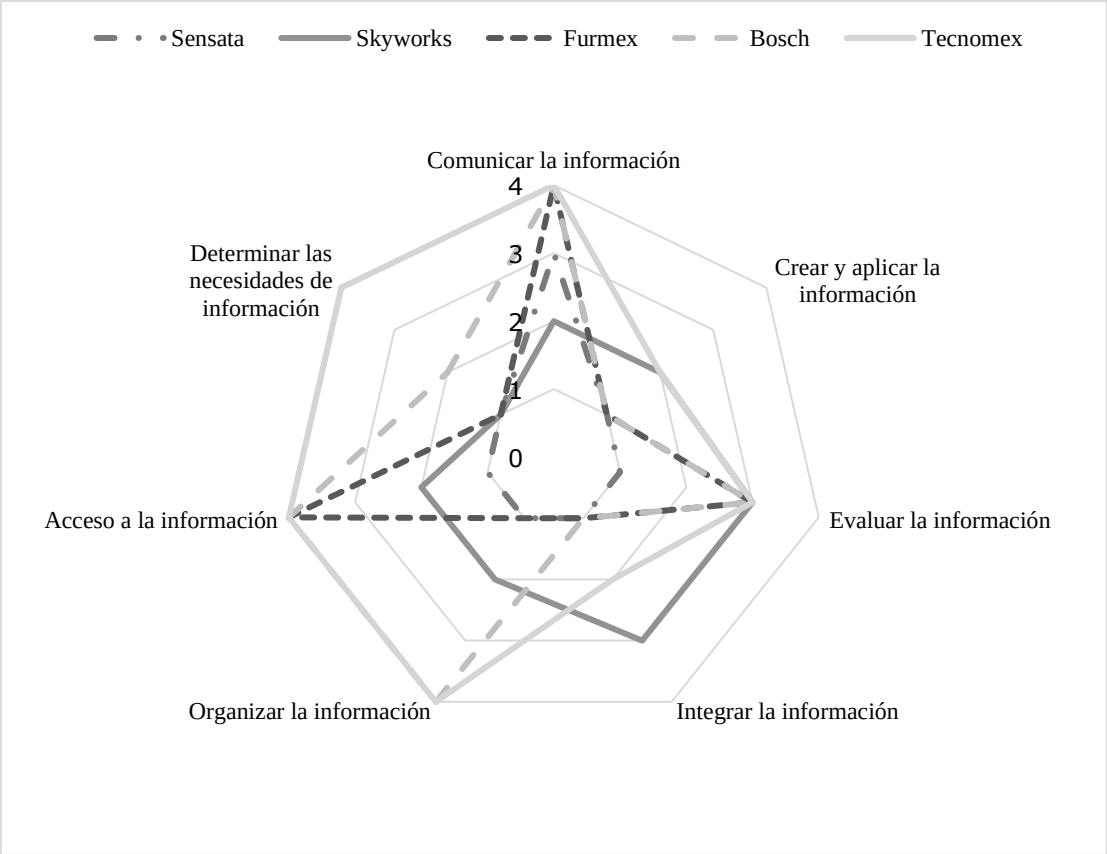
As in the case of engineers, three dimensions of digital skills were analyzed for operators: competencies for digital information processing, competency for the use of digital tools, and personal competencies.

When interviewing the operators of each company about their last school grade completed, it was found that in three of the five companies the employees did not have basic studies, since they reported having only a high school education. According to the Norma de Escolaridad Obligatoria del Estado Mexicano (NEOEM, by its acronym in Spanish), proposed by the Instituto Nacional para la Evaluación de la Educación (INEE, by its acronym in Spanish), if a person over the age of fifteen does not have basic education, he or she is considered to be behind in education.

Digital information processing

In the processing of digital information, it was found that there is a clearer deficiency in the positions of operators than in those of engineers, since most report a knowledge level of 1 to 3 on average, indicating that they have no notion of the technology or use it in a basic way; However, one Tecnomex operator who reported having only a high school education showed quite developed skills in digital information processing, with a knowledge level in the field studied of 3 to 4, i.e., he processes digital information effectively, although with some exceptions (see figure 6).

Figure 6. Processing of digital information



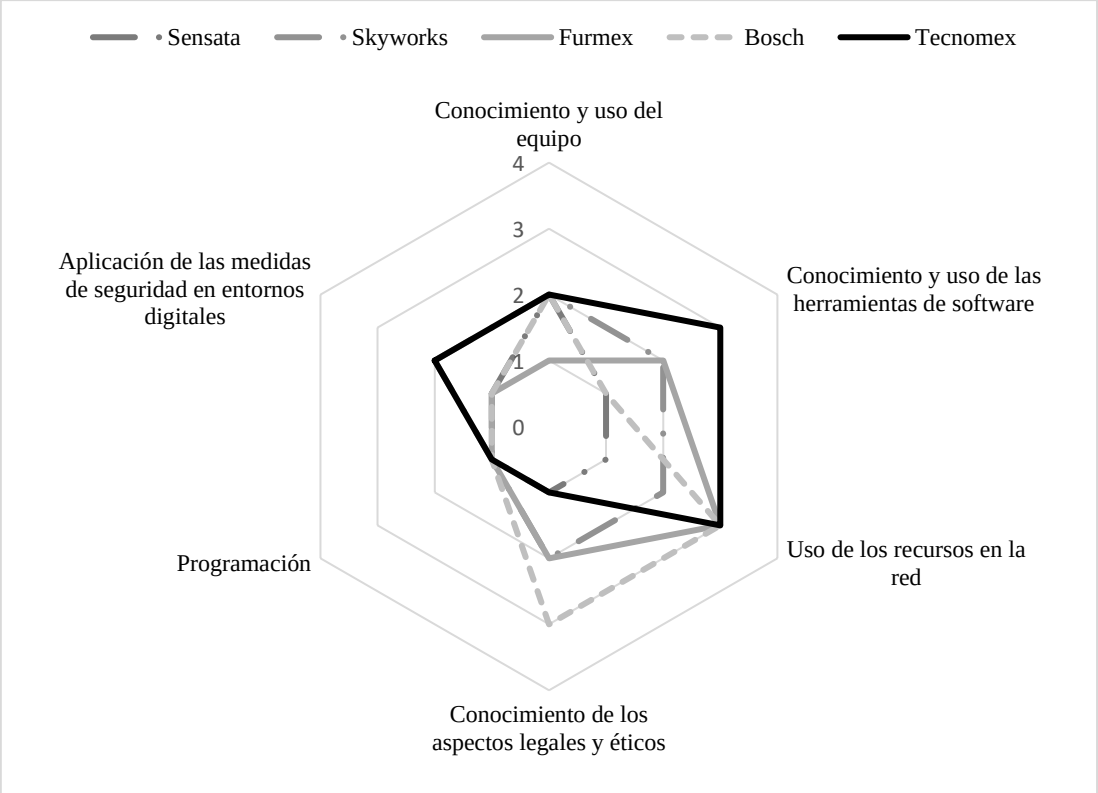
Source: developed by the author, based on interviews with operators.

Skills in the use of digital tools

The level of expertise of the operator's knowledge, skill and ability in the application of technologies was analyzed. The operators of the five companies studied reported a degree of

understanding and ability of 1 to 2 in most of the tools, i.e., they do not know the technology or have little information on how to use it (see figure 7).

Figure 7. Skills for using digital tools

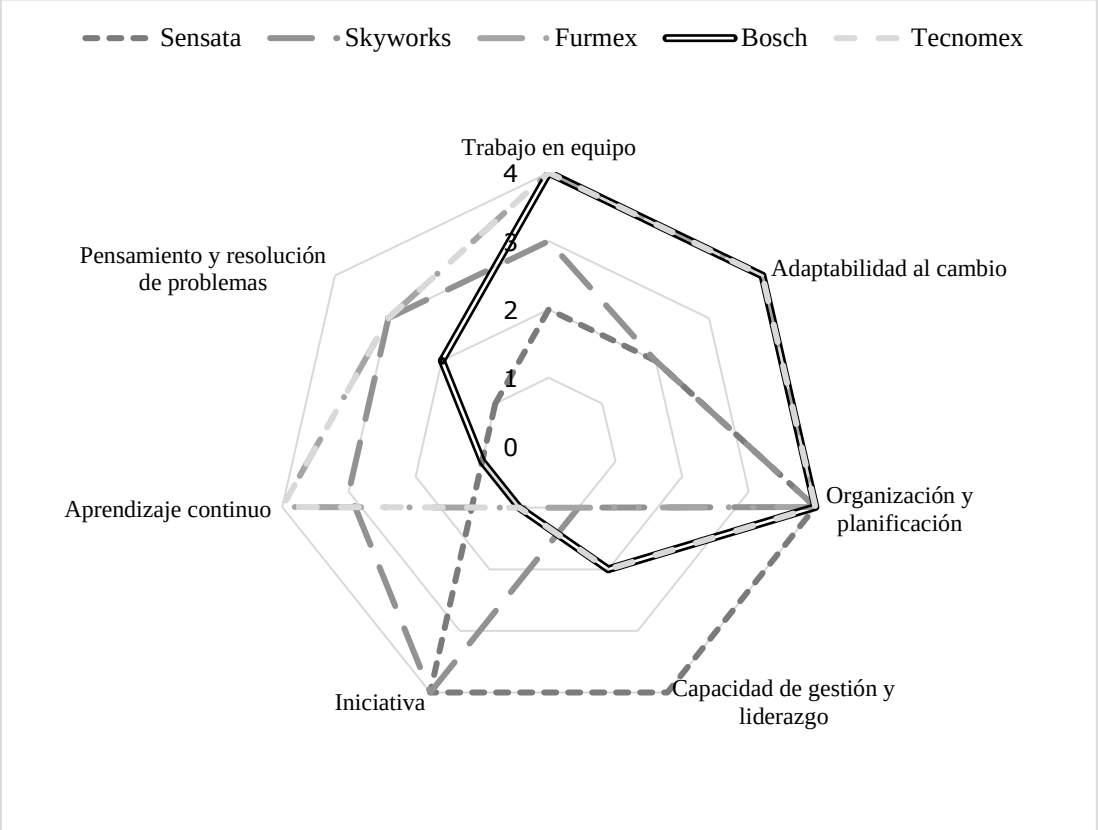


Source: developed by the author, based on interviews with operators.

Personal competencies

It was found that the operators present a level of 2 to 4 in the personal competencies that contribute to increased performance in their work, which means that the workers are aware of and committed to the mission and vision of the organization, in addition to actively contributing to the improvement of the organization (see figure 8).

Figure 8. Personal competencies



Source: developed by the author, based on interviews with operators.

Hiring trends in the labor market

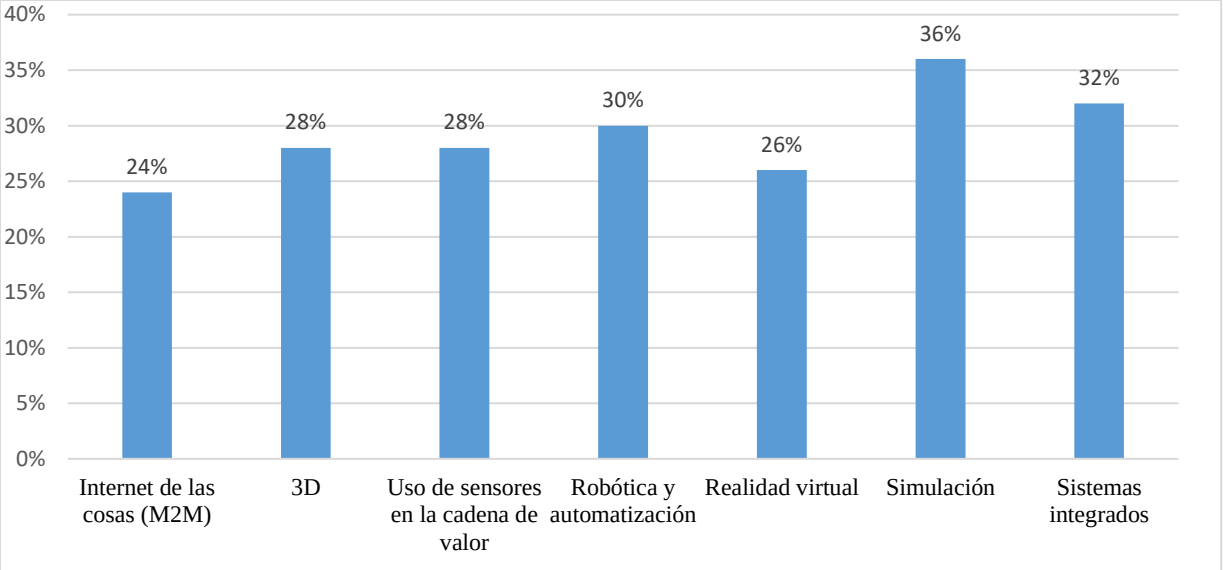
The five human resources representatives of the companies assured that the effects of the incursion of new technologies in the industrial value chain will bring about positive changes for this labor market. It is important to mention that none of them stated that there could be cuts in engineering positions due to the implementation of Industry 4.0.

In addition, the representatives considered that it is likely that the current low-skilled job demand will not exist in the future. Four of the interviewees consider that, among the effects that the implementation of new technologies will have on the operator level, include displacement to new positions, new training needs and salary increase; however, one of the five representatives stated that the result of the new digital era will bring layoffs and cutbacks in job profiles.

The results obtained on the percentage of jobs likely to disappear due to new technologies in the coming years show a range of 24% to 36% (see figure 9), depending on the type of technology. In addition, human resources representatives state that these

technological innovations will, in turn, create new jobs, almost at the same level at which they are expected to disappear, between 26% and 32%.

Figure 9. Job elimination level

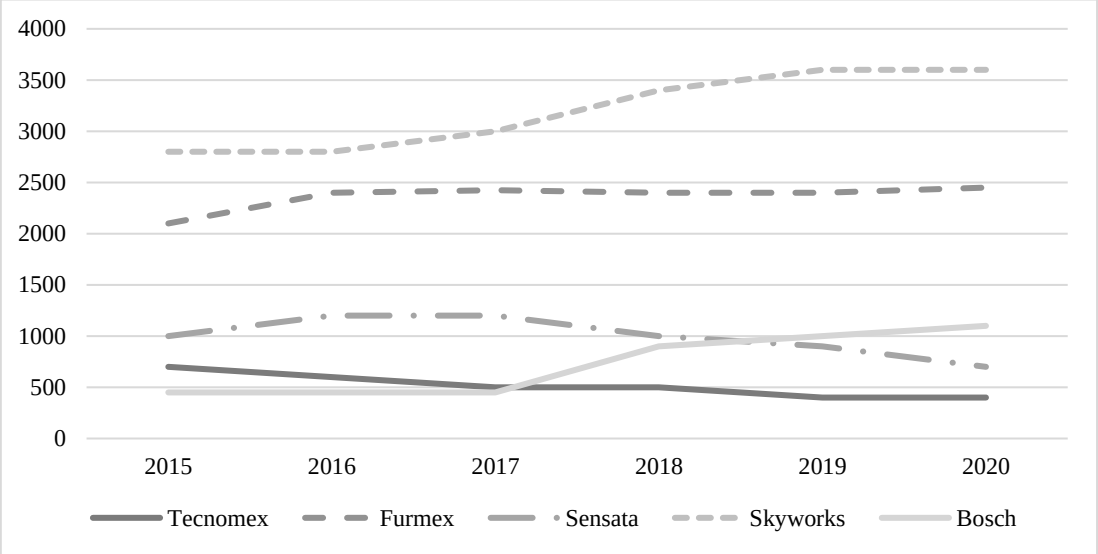


Source: developed by the author, based on the data obtained from the interviews applied to the human resources representatives.

In order to determine a hiring trend, human resources representatives were asked for an average number of employees the company has had in the last five years. Figure 10 shows that Sensata has a tendency to reduce its workforce, which coincides with the level of digital maturity it reports, as it presented a level of 3 to 4 in most Industry 4.0 technologies. This implies a level of utilization and knowledge of 75% to 100%.

In the case of Tecnomex, it reported a digital maturity level of 2 to 3, which shows a utilization and knowledge of 50% to 75%, i.e., the company uses or has used certain technologies in some processes or pilot tests. In addition, like Sensata, it shows a decrease in headcount. The Skyworks and Bosch companies presented a maturity level of 2 to 3, and according to the informants from the human resources departments, in the last five years they have steadily increased their workforce. Finally, Furmex reported an intermediate maturity level, from 2 to 3, which indicates that its level of use and knowledge is between 50% and 75%. Regarding the number of employees per year, the company indicated that its workforce has remained relatively constant.

Figure 10. Number of direct employees per year



Source: developed by the author, based on the data obtained from the interviews applied to the human resources representatives.

Plans and strategies of the maquiladora industry

In order to investigate the plans and strategies of the maquiladora industry in the region in relation to the implementation of Industry 4.0 and the effects it will have on employment, we interviewed the former president of the Consejo Nacional de la Industria Maquiladora y Manufacturera de Exportación A.C. (INDEX, by its acronym in Spanish), Arturo Lara, and the president of the Information Technology Cluster in Baja California (ITbaja), Victor Sanchez. (INDEX), Arturo Lara, and the president of the Information Technology Cluster in Baja California (ITbaja), Victor Sanchez.

Regarding the elimination of jobs, the first informant assured that the industry's technologies will displace low-skilled labor, due to the high demands of knowledge and specialization required by the new jobs. In addition, he agrees that, due to new technologies, new labor needs will arise that will create jobs where scientific, analytical and technological knowledge is required to perform adequately. Other areas that have the potential to increase employment are those related to research and development of new technologies.

Likewise, the director of ITbaja pointed out that the challenge of Industry 4.0 encompasses interconnected production environments, such as the capture, management and transmission of large volumes of data, communications security, intelligent information analysis and self-managing production lines, as well as increasingly autonomous facilities.

In another category, labor inequality was analyzed, and the interviewees agreed that workers who fail to train and educate themselves in technological, scientific and information technology careers will be left behind in the labor market, especially in the manufacturing sector. According to the former president of INDEX, this is why instruction of individuals is increasingly demanding.

Discussion

Industry 4.0 is a highly technological manufacturing system, which represents billions of dollars of investment in machinery and technology. Many of the maquiladora industries in the region are foreign, so they maintain their innovative technologies and do not transfer them to other countries until others emerge and replace them. For Salazar (1990), the transfer of new technologies to the country is restricted or determined by the availability of qualified personnel.

The research results show that the degree of incorporation of the Mexicali electronics subsector in the digital maquiladora industry is mostly at a maturity level of 2 to 3, which means that companies use technologies from 25% to 75% on a regular basis. Therefore, it is possible that they are still in the planning stage of digital transformation, since, according to the hiring rate reported by the companies in the last five years, there has been an increase in the hiring of direct personnel in three of the five companies, which evidences the dependence on labor in the productive processes.

Tecnomex reported a medium maturity level, from 2 to 3, and its workforce has decreased, which may be due to the fact that the loss of employment was one of the first symptoms of the global economic slowdown of the last five years, due to the increase in tariffs, global trade tensions and the great political uncertainty originated by the two main world powers: China and the United States (United Nations 2020).

The results of the digital maturity analysis reaffirm what was said by the Instituto para el Desarrollo Industrial y el Crecimiento Económico A.C. (IDIC, by its acronym in Spanish) (2019), which points out that industry in Mexico is in the planning stage of digital and technological modernization, which positions the nation at a disadvantage in relation to highly industrialized countries. Currently, studies have begun to emerge in our country on the level of incorporation of Industry 4.0 and the effects on employment, while in first world industrialized countries there is extensive research on the subject. An example is the study conducted by the General Union of Workers of Castilla y León (UGT, by its acronym in Spanish) (2017) in Spain, where it was found that the industry of some sectors presents in a medium-high level of maturity.

To achieve being competitive in the working world and in the new digital era, it is essential to have digital skills (Harangus *et al.*, 2018, cited in Inzunza and Espinoza, 2018),

which comprises knowledge, skills and professional attitudes in ICT. The results of the analysis on the level of digital skills in engineering and operations positions show that there is a gap in digital knowledge and skills between the two positions. Engineers reported having extensive knowledge and skills in Industry 4.0 technologies.

In the region's maquiladora industry, an operator's technology-digital skills play a definitive role in job tenure. Digital skills give workers the necessary weapons to cope with the new digital era; however, it was identified that in operators' positions there is a lag in digital skills and competencies. In addition, their level of education is a constraint in the development of their work, since a limited degree of knowledge can be a barrier to scientific-technological learning.

This implies a challenge for the country in terms of education and job creation, since digital skills are currently a requirement in the labor market, especially in the manufacturing sector. In this context, research conducted by UGT (2017) showed that, in Spain, unskilled personnel have lost their jobs, and new positions requiring higher skills have been created.

According to the interviews conducted in this research, changes in the needs of the labor market in our country and in the locality are foreseen, so workers will require new techno-digital skills to face the challenges presented by Industry 4.0, in the medium and long term. Likewise, informants consider new technologies as an opportunity to develop workers' skills; however, they cannot assure that all people want or can continue training and acquiring new knowledge, since their capacity to understand is limited by their level of studies. Moreover, they are not certain that their company managers are willing to invest in these trainings.

It is likely that there is a polarization of employment in this sector, forcing people with a low level of education to accept very low-paying jobs. Authors such as Schwab (2016) point out that the fourth industrial revolution will lead to wage inequality and loss of the value of work, and the most skilled people, such as engineers, will have a higher income. For the case study of Spain, the UGT (2017) pointed out that Industry 4.0 will not eliminate employment, but will reorganize it and create others; however, it stated that, in the face of new high-skill requirements, displaced jobs will be absorbed by other sectors.

It is likely that the maquiladoras in our country will maintain their technological level for a few more years, because the lack of qualified operators or technicians makes it unnecessary to bring in this technology; however, there are two factors that could turn the story around: 1) the labor shortage in the maquiladora sector, which could cause companies to invest in highly automated and artificially managed processes to continue production, and 2) the global pandemic due to Covid-19, which since March 2020 has not allowed companies to work at their normal pace, due to the fact that their workers may be affected in their health.

Conclusions

The effects of the incorporation of Industry 4.0 in the maquiladora sector in the region are not yet fully visible, due to the medium level of digital maturity of the companies. Also, despite the fact that there have been some cuts in operations personnel in the last five years, the productive systems still base the productive force on labor; however, it is a fact that Industry 4.0 will be experienced differently for engineers and workers. As new technologies advance and are incorporated into the industrial sector, it will become more attractive to hire engineers to ensure competitiveness and business quality, which will leave behind low-skilled workforces.

It is important to point out that the turn of the electronics manufacturing industry in the region requires strategies designed and coordinated among the agents involved (companies, unions and government institutions such as the Ministry of Economy, the Ministry of Education and the Ministry of Labor and Social Prevention, among others) to promote the transformation of human capital towards the development of skills and competencies to meet the new challenges of Industry 4.0 and, simultaneously, to design and promote policies to counteract the increase in the number of workers with low education and limited or no knowledge of digital techniques.

To meet this challenge, it will be important to expand and ensure new educational programs that take into account the needs of the labor market, in addition to training the sector of workers who are willing to continue with their preparation. In addition, it is important to reinstate workers who are not in a position to continue their school certification and technical training, since they would be the first profiles to be left without the opportunity to opt for a job in the manufacturing sector.

Therefore, this work reiterates the importance of conducting further research from different perspectives, from other industry sectors and other geographical spaces, which would lead to add findings to create a guiding basis for future public policies in the field of educational and technological training, taking into account the demands, forms and rates of incorporation of Industry 4.0 in some regions of Mexico.

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[1] The current government increased the minimum wage in the border area from 176.72 pesos to 185.56 pesos placing it, according to Navarro (2019), a few cents above the basic market basket; however, as stated by Azuela *et al*. (2019), this increase is still not enough, because despite being a wage that considers keeping workers out of extreme poverty, it does not save them from living with a precarious quality of life.

[2] "Uber is a technology company. Using its app, users who need transportation can easily find driver-partners who offer this service. Uber offers one more option to move around the city, with more style, safety and comfort than ever. Present in more than 310 cities around the world" (Uber, 2015).

[3] Tariff rate 807.00 added the U.S. tariff rates in the Economic Factors Affecting the Use of ltems 807.00 and 806.30 of the Tariff Schedules of the United States, which was a customs simplification that allowed importing and exporting duty-free components, except for the value added abroad (Carrillo, 2001).