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## Analysis of Industry 4.0 Products in SMEs

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### Abstract

The implementation of ICTs in different functional areas of a company determines the added value to the transformation process towards Industry 4.0. The incorporation of technologies requires knowledge of the specific existing products and those that can be incorporated in a process of replacement and gradual integration between the Software, Hardware, and Infrastructure necessary for operation. To detect the level of insertion of these technologies within an Industry, the GIS research group has created an Index that relates these technologies to production processes and allows evaluating their degree of insertion, linking ICT products, the functions they fulfill, the size of the company and the branch of activity. This article introduces the results of a study carried out by applying the index in a highly industrial region of Argentina, where the products that make up Industry 4.0 and their implementation in the real context of use of the companies surveyed are analysed in detail.

*Keywords:* ICTs Index; Technological Development; Industrial Development; Industry 4.0

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### 1. Introduction

Industry 4.0 represents the end-to-end technological integration of each of the value chains, which extends from smart factories to the dizzying changes in mass consumption in different markets. The impact of this transformation imposes substantial technological changes in the multiple productive sectors, since the competitiveness of companies goes through globalization, productivity, innovation, and the incorporation of technology as a pillar of development.

The digitalization process deploys generating an increase in the technological heterogeneity of the industries, deepening the structural gap previously existing in the fourth industrial revolution accelerated by the Covid-19 pandemic. This transformation is projected as a negative effect on the different regions worldwide, where many companies could disappear depending on their size, the industry to which they are dedicated, as well as the geolocation and socio-economic context where they are located.

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The gap in the digitalization of companies in Latin American countries is widely significant [1] and is at risk of increasing in the coming years with the accelerated evolution of Industry 4.0. The Inter-American Development Bank (IADB), in a recent study on the region, recommends public and private initiatives to support small companies in the use of technological solutions for their operations [2].

To analyze the level of digitalization that companies will face in in the next 5 to 10 years, the IADB created a Conditional Digitalization Index (IDC) [2] based on three factors: the digital tools currently adopted by companies, the digital scenario in which each company hopes to be in the future, and the level of preparation to achieve the objectives. This IDC also assesses the use of technologies in company relationships with suppliers, in production management and in customer relationships. In this way, it allows evaluating the "perception" of companies about digitalization in 2030, what the impact of digitalization will be in the future, measured by current actions on a set of indicators that are not limited to the adoption of technologies. However, it does not detail which digital tools are available or which are adopted by companies, that is, it analyzes the current transformation process from the "perception" of the companies themselves, without determining the products that make up Industry 4.0. Its application is carried out with a survey through which companies indicate which of the descriptions of 4 possible digital generations best fit the practices to perform most of the routines of each function.

With these instruments, the IADB carried out a comparative study between Argentina and Brazil, taking 256 Argentinian companies and 474 Brazilian ones in the period 2019-2020 [2], the results of which expose a worrying panorama about the perception of the companies themselves towards digital transformation.

In this context, it is possible to analyze that the self-perception of companies in the region includes ignorance about the available technologies, about the adoption processes and about the technological potential for their business.

From this perspective, given the speed of the transformation process and the companies' lack of knowledge about the decisions to be made, it is necessary to know which are the specific technological products that make up Industry 4.0 and provide information on the path of adoption and complementarity they acquire. these technologies.

For this purpose, some work has been done on the InTICs® Index [3] [4] created by the GIS research group (Grupo de Ingeniería de Software) that evaluates the level of technological development of each industry according to the Software, Hardware, and Infrastructure products that it has implemented, currently fulfilling specific tasks in the different functional areas. This index makes it possible to detect specific products and select the subset of technologies that make up Industry 4.0 implemented in each company.

The index was applied in a study on a highly productive district of the province of Buenos Aires, in Argentina, where 40 manufacturing industries were evaluated in the period 2019-2020, to assess the current level of technological development, the products necessary to develop and implement in companies, and the transformation path towards Industries 4.0 that companies in the region should travel.

## 2. Materials and Methods

The InTIC's® index applied is structured from the technological products differentiated into 3 ICT components: Software, Hardware, and Infrastructure [5] grouped according to the specificities of each type of technology and implemented in the functional areas where these technologies fulfill specific tasks within industries.

The generic functional areas that the index differentiates are the following.

- Management
- Accounting and Finance
- Engineering
- Purchases
- Logistics
- Production
- Sales

Once the technological products have been identified in their intersection with each functional area, the index generates an assessment of 3 levels, weighing each product according to its degree of development in terms of the time of validity in the market of each one of them, allowing to distinguish the score of each company according to the technology implemented:

- *Basic level* for those companies that have old technology
- *Medium level* for those companies that have medium current technology
- *Advanced level* for those companies that have advanced technology

The ICT products identified by the index are 74 in the different functional areas, within which those corresponding to the basic level are 20, those of the medium level are 30 and those of the advanced level are 24. Not all the products included in this last advanced level are of the latest generation, but they are essential for the integration and operation of the others, therefore, from this set it is possible to extract the subset of specific products from Industry 4.0. Figure 1 shows the specific products of the index that, when integrated, make up the subset of products of Industry 4.0.

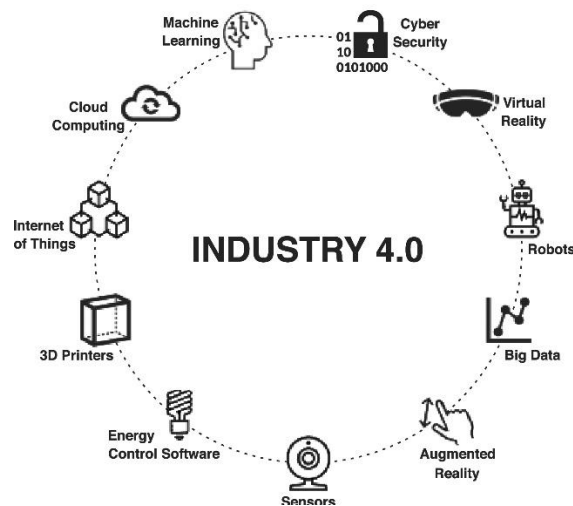


Fig. 1. Enabling ICT Products for Industry 4.0

A study was carried out applying the InTICs ® index in the industrial sector of the district of La Matanza, the largest district of the Province of Buenos Aires, Argentina with 2 million inhabitants and 7.000 industrial establishments from different sectors of the manufacturing industry and conformed by small and medium-sized companies in its vast majority.

40 industries of various branches were surveyed between 2019 and 2020 to determine the level of technological development and detect the existence of Industry 4.0 products implemented in local companies. The survey was carried out through a digital survey, which is linked to an index calculation software, informs each company of the level obtained and is accessible via the web (<https://indicetics.unlam.edu.ar/it/>).

Next, the ICT products of the advanced level that make up a subset of 10 enabling technologies Industry 4.0 are described.

**Virtual Reality:** Virtual Reality is a three-dimensional environment generated by computers that create in the user the sensation of being immersed in it. This environment is visualized through Virtual Reality glasses, and sometimes accompanied by other devices, such as gloves or special suits, which allow greater interaction with the environment, as well as the perception of different stimuli that intensify the sensation of reality [6].

**Robots:** The equipment that performs some function of physical movement through artificial mechanics are considered Robots and are made up of computers that contain an electromechanical system composed of

microprocessors and software that orders the development of automatic repetitive tasks independent of human control.

***Big Data:*** Big Data is understood as a set of techniques tending to make decisions in real time that involve a large volume of data typically coming from different sources. The eCommerce projects find in Big Data techniques a tool to maximize the conversion rate. Big Data is usually characterized by three attributes: volume, variety, and speed. The processing of Big Data requires non-SQL databases, capable of managing unstructured and structured data [7].

***Augmented Reality:*** Augmented Reality is the real-time visualization of visual and/or auditory virtual elements superimposed on a real-world environment. Thus, while Virtual Reality allows users to experience a completely virtual world, Augmented Reality adds virtual elements to an existing reality, rather than creating that reality from scratch [6].

***Sensors:*** At the beginning of the process chain, the greater efficiency of the resources depends to a large extent on the equipment that supplies this data, and that is where the Sensors acquire great importance. To implement the concepts of Industry 4.0 in the automation industry, sensors not only have to provide signals or measured values, but also need to be communicated. The information provided by the sensors is the first factor that offers the ability to see, detect and intelligently communicate to the machinery and the operator who observes the process through the management system.

***Energy Control:*** The software that allows to control energy consumption requires electrical devices or sensors that, in a centralized and automated way, from any personal desktop computer, collect consumption data. This type of platform allows companies to have a comprehensive control of lighting and electrical equipment in general, allowing to adopt energy saving strategies based on time schedules, occupation of areas and lighting levels. By incorporating measurement sensors, the system can increase the number of strategies that can be implemented; for example, considering the amount of sunlight available, tasks that are being performed, employee preferences, among others.

***3D Printers:*** 3D printers are made up of a set of technologies of manufacturing by addition, where a three-dimensional object is created by overlapping successive layers of material. One of the main benefits is associated with flexibility, since specific machinery whose function is limited to a particular product is replaced. They allow to improve communication, by having a realistic 3D model in full color to convey much more information than with a computer image [7].

***Internet of Things:*** Currently, the products used in the field of smart cities, within the context of the Internet of Things, are focused on an infrastructure based on cellular communication or through Wi-Fi Networks. In all these cases, the need arises for lower energy consumption, especially in the case of terminal equipment that is powered by batteries. To this, better reach and penetration options must be added, difficult to obtain with the previous options. There are several proposals that are pushing today to achieve their supremacy in this new world of connected things. The most renowned today in terms of connectivity are ZigBee, ZigFox, Z-Wave, LoRa and NB-IoT, among others.

***Cloud Computing:*** Cloud Computing refers to the use of computer applications and services hosted externally, and typically accessed via the Internet. It includes concepts such as SaaS (Software as a Service), IaaS (Infrastructure as a Service) and PaaS (Platform as a Service). The main benefit of Cloud Computing is associated with the fact of dispensing with the own infrastructure necessary to run applications: servers, eventual databases, or even the application itself, requiring only Internet connectivity. The Cloud Computing model frees up capital for other areas of the business, since typically the initial charges, when there are any, are much lower than those that would be necessary to generate its own infrastructure. In general, the Cloud Computing model offers high scalability, allowing services to be adjusted to the volume of the business, and implies a high dependence on the provider, who must be carefully selected, and on the Internet connectivity, which is critical [7].

***Machine Learning:*** This concept refers to a data analysis method that automates the construction of analytical models. It is a branch of artificial intelligence based on the idea that systems can learn from previous data, and thereby identify patterns and make decisions with minimal human intervention from the programming of an algorithm. The iterative aspect of Machine Learning is that as the models are exposed to new data, they can be adapted independently. They learn from prior calculations to produce reliable and repeatable decisions and results.

***Cyber Security:*** Cyber Security is based on the implementation of techniques and applications to ensure the integrity, privacy, confidentiality, and availability of the assets belonging to the information systems of organizations against internal and external threats. An adequate implementation of Cyber Security can divert and reduce potential

intrusions and threats to information systems. The time that a session remains active without activity, the minimum characteristics of passwords, access profiles, intrusion prevention and denial of service, are simple examples of some of the topics addressed by Cyber Security [7].

### 3. Results and Discussion

The results of the study allow to analyze a distinction by size in the universe of the 40 companies surveyed, where 45,00% are micro-companies (up to 15 employees); 25,00% is made up of small companies (up to 60 employees), another 17,50% is in the medium category section 1 and section 2 (up to 235 and 655 employees respectively) and 12,5% are located in the large category company (more than 655 employees), as can be shown in figure 2.

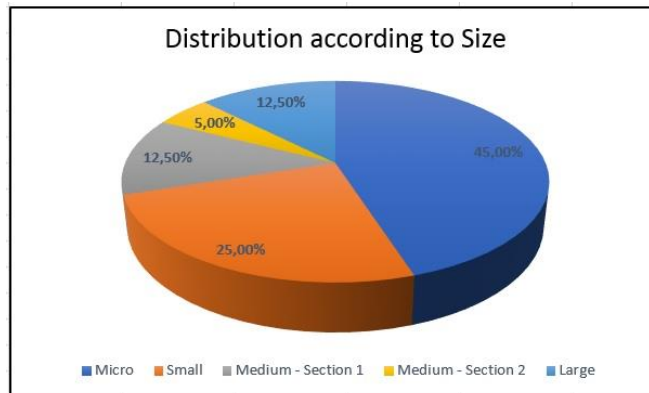


Fig. 2. Distribution according to Size

From the analysis of the results applying the index; of the 40 industries surveyed, 62,50% are in the basic level, 35,00% in the medium level and only 2,50% in the advanced level, as shown in figure 3.

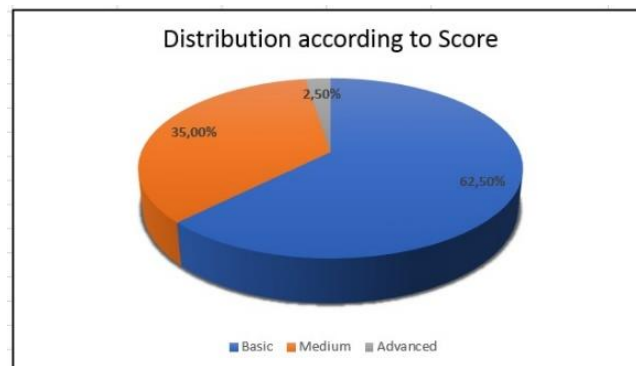


Fig. 3. Distribution according to Score

Analyzing the implementation of the subset of ICT products that make up Industry 4.0 in the universe of companies surveyed, the results described below are shown.

There are 3 companies that have *Augmented Reality* software implemented, belonging to the metallurgical sector. 1 large company, 1 medium-sized and 1 small company that apply this type of technology to product and process

design systems in the functional areas of sales and/or production. Of these companies, 1 has an advanced level according to the ICT index, while 2 have a medium level; as shown in figure 4.

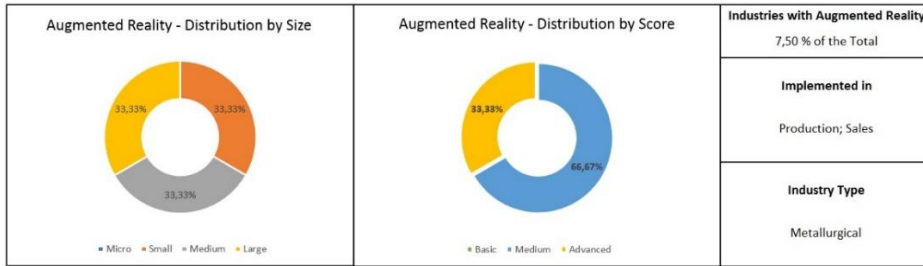


Fig. 4. Industries that implement Augmented Reality

The companies that have *Virtual Reality* software are 3. 1 large, 1 medium and 1 small company, of which 2 are from the metallurgical sector and 1 from the paper industry. Its implementation applies to product and process design systems for sales and/or production functions. Of these companies, 1 has an advanced level according to the ICT index, while 2 have a medium level; as shown in figure 5.

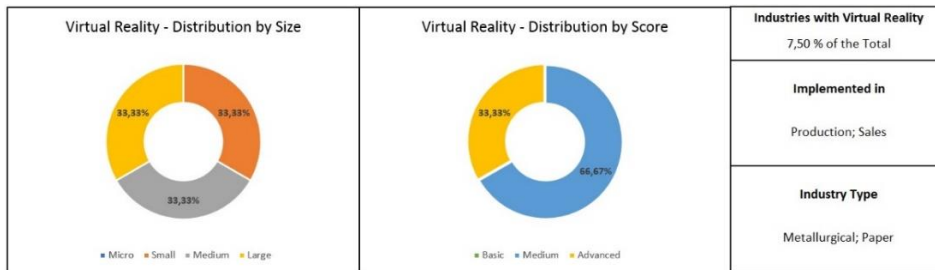


Fig. 5. Industries that implement Virtual Reality

There are 6 companies that use *Big Data* software, and their implementation is applied for management systems that combine information from different functional areas, such as management, accounting and finance, sales, purchases, logistics and/or production. Of the 6 companies, 1 is a large company and 5 are medium-sized. 2 of them produce in the metallurgical sector, 1 is a plastic manufacturer and 3 belong to the software and computer services industry. Of these companies, 1 has an advanced level and 5 are located at a medium level; as shown in figure 6.

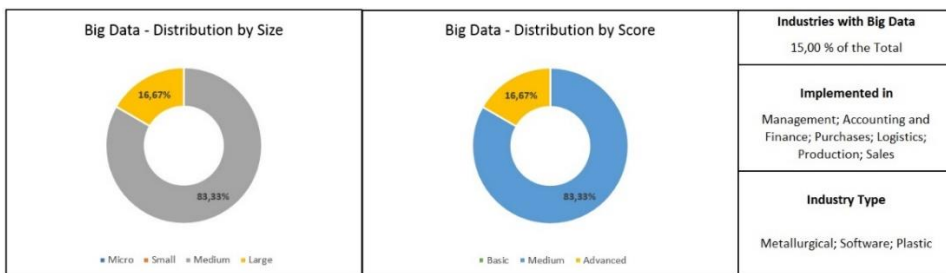


Fig. 6. Industries that implement Big Data

Regarding the use of *Robots*, from all the 40 industries surveyed, 6 have automated plants with the assistance of robots for production, 3 of which are large companies, 2 belonging to the food sector and 1 to the metallurgical

sector, in so much so that the other 3 are small companies in the leather and metal branches. Regarding the level of development detected by the index, 1 is in the advanced level, 3 in the medium level and 2 of them in the basic level of ICT implementation; as shown in figure 7.

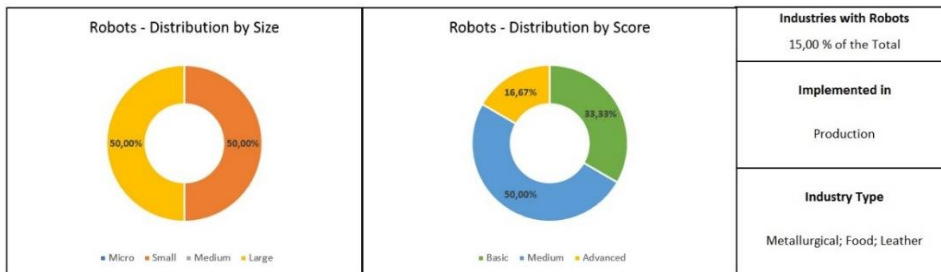


Fig. 7. Industries that implement Robots

There are 11 industries that have *Sensors*. These devices are used by all those industries in their production line, while some complement them with devices installed for the engineering, logistics or sales area. Regarding its level of development evaluated by the ICT index, 1 company is in the advanced level, 9 are positioned in the medium level and only 1 in the basic level. Regarding their conformation, 2 are large companies, 3 are medium-sized, 4 are small and 2 are micro-companies. Regarding the branches, there is a variety of sectors, such as metallurgical, textile, leather, food, and paper; as shown in figure 8.

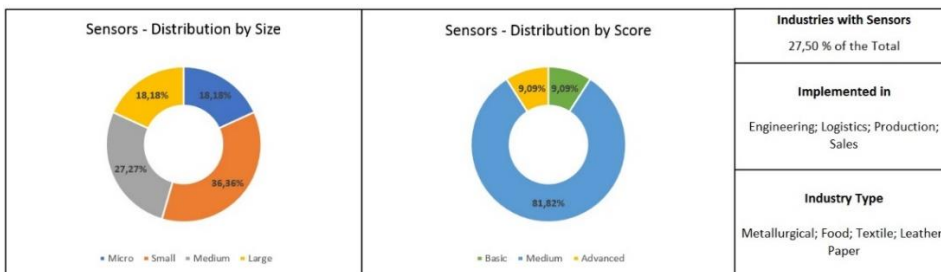


Fig. 8. Industries that implement Sensors

13 companies have networks for the *Internet of Things*. This technology has been implemented by 10 companies that have Sensors installed, 2 that have robots in their plants and 1 company that has reported that it has this infrastructure, but does not declare any device installed. In all cases, they use this infrastructure in combination to carry out tasks in all the functional areas of the ICT index. Of the 13 industries, 1 is at the advanced level, 8 are positioned at the medium level and 4 at the basic level. In terms of its conformation, 2 are large companies, 5 are medium-sized, 4 are small and 2 are micro-companies. Regarding the branches, there is a variety of sectors, such as plastic, metallurgical, textile, leather, food, paper, software, and computer services; as shown in figure 9.

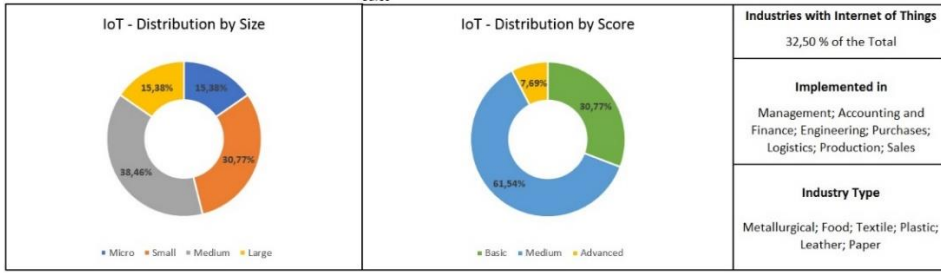


Fig. 9. Industries that implement Internet of Things

Regarding *3D Printers*, 5 companies that have this equipment have been surveyed, 2 implemented in the management area, 2 in the sales and engineering areas and 1 company combines the use in production, sales and management, 4 of them integrating the metallurgical sector and 1 to the software and computer services sector. Of these industries, 1 is located at the advanced level and is a large company, 3 at the medium level and its size is medium, while only 1 is located at the basic level and is a micro-company; as shown in figure 10.

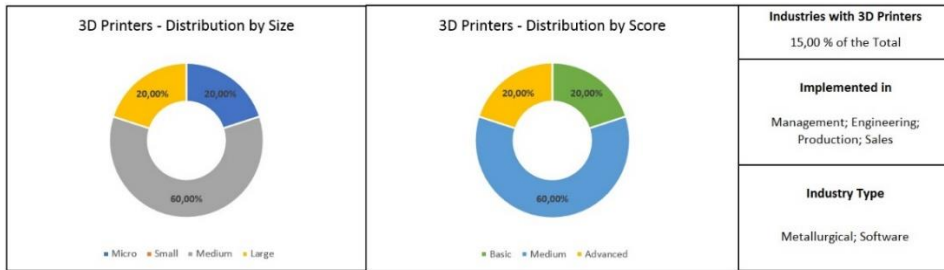


Fig. 10. Industries that implement 3D Printers

Regarding the *Cloud Computing* service, of the 40 companies surveyed, 16 are those that use this infrastructure in a combined way to carry out tasks in the seven functional areas of the ICT index. Regarding the branches, 5 belong to the software and computer services industry, 4 to the metallurgical sector, 3 to the plastic sector, 2 to the food sector, 1 to the textile sector and 1 to the manufacture of electronic components. According to size, 2 are large companies, 7 are medium-sized, 6 are small, and 1 is micro. 1 of the large companies is at the advanced level, while 10 are at the medium level and 5 are at the basic level; as shown in figure 11.

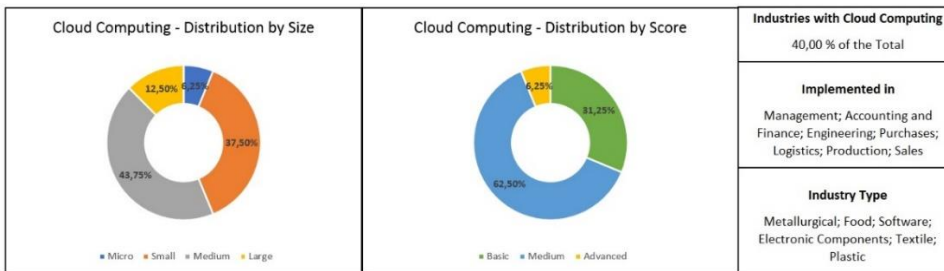


Fig. 11. Industries that implement Cloud Computing

There are 6 companies that use software with *Machine Learning*, of which 1 is in the advanced level and 5 in the middle level of the index. In all cases, its implementation is applied to management systems that combine



information from different functional areas of the company such as production, logistics, sales and/or management. According to size, 1 is a large company, 3 are medium-sized and 2 are small; while 3 belong to the metallurgical sector and 3 to the software and computer services industry; as shown in figure 12.

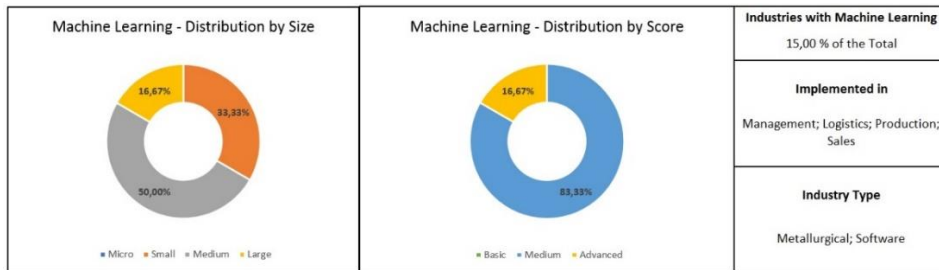


Fig. 12. Industries that implement Machine Learning

Regarding the implementation of software with *Cyber Security*, 16 industries use Critical Infrastructure Security Systems to perform tasks in all functional areas of the company. Regarding the branches, 5 belong to the software and computer services industry, 5 to the metallurgical sector, 3 to plastic, 2 to the food sector, 1 to the furniture sector. According to size, 2 are large companies, 7 are medium-sized, 6 are small, and 1 are micro. 1 of the large companies is at the advanced level, while 10 are at the medium level and 5 are at the basic level. 10 out of 16 industries use Cyber Security as a complement to all the functional areas; as shown in figure 13.

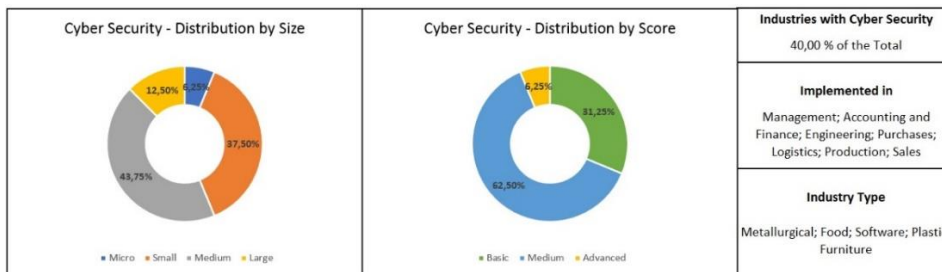


Fig. 13. Industries that implement Cyber Security

Regarding the availability of *Energy Control* software, none of the 40 industries surveyed has technology aimed at energy efficiency.

From the total number of companies surveyed, only one is within the Industry 4.0 group, given that it has all the index products at the advanced level, including all the products of the Industry 4.0 subset. It is a large company in the metallurgical sector, a multinational metal producer company. In this sense, the provision of an IT area, with own developments and experience in the infrastructure implementation, is a determining characteristic to be able to locate in that place of technological development.

On the other hand, within the group of 18 companies that are in the medium level of the index, in general they combine a large part of the 24 products of their level with some technologies of the basic level and occasionally with products of the advanced level. Only a few companies at this level have implemented a product from the Industry 4.0 subset to fulfill a specific function, but without integration into the company as a whole. Something similar happens with a few companies of the basic level, which occasionally have implemented an advanced product that makes up the subset of Industry 4.0.

#### 4. Conclusions

In this article, the result of the application of the InTICs® index has been introduced, which allows evaluating the level of technological development in the manufacturing industry discriminated by region, branch of activity or company size. The structure of the index makes it possible to differentiate into 3 levels of technological development according to the specific products that each company has implemented and to extract the subset of products that make up Industry 4.0. In this way, the advanced level that defines the index constitutes the base of the industries that are in the process of technological transformation towards Industry 4.0.

The analysis carried out distinguishes between existing technologies and trends in the development of specific products, which provide companies with knowledge about them according to the time they have been available in the market and the needs for implementation and integration of necessary Software, Hardware, or Infrastructure.

Likewise, the results of a survey carried out in 40 industries in a district of Argentina have been shown, where an important technological gap is observed between a large multinational company in the metallurgical sector and the majority of SMEs that incorporate technology without a strategic vision on the features they need to deploy to increase their productivity.

The results of the study allow to conclude that it is possible to apply the index to determine the level of technological development and generate information on technologies that is useful for making strategic decisions on investment and productive development both in a particular company, for a chain of value in a specific branch, as well as for the definition of public policies.

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