

Recommendations for the Production Lines of the Future Factory in Colombia

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Abstract

The objective of this research is to identify the main recommendations that need to take into account the production lines of the factories of the future in Colombia, with prior warning of a brief analysis of the current panorama of the country and the identification of the main challenges linked to the processes of change and adaptation of the new technological trends associated with the productive sector, attempting to provide effective tools that allow optimal entry to the factories within the framework of the Smart Factory.

Keywords: Smart Factory, Innovation, IoT, Infrastructure and middleware, Human talent, Robotics, Data Analysis.

INTRODUCTION

The technological and research progress has managed to reach different areas of the economy, which leads to adapting and interacting with the new findings that are revealed little by little. Although in countries of the first world there is a change in the way factories do their activities, for example, adding new technologies that facilitate the interaction of each of its subsystems in order to add value to their products; In developing countries it is necessary for large corporations to venture into technological development through which they achieve a better flow of information, inputs and money.

It is expected in the world, from this year until 2022, [1] the market for smart factories to have a growth of 9.3%, for which, it is necessary to implement intelligent robots within them, to adopt the Internet of things (IoT) as an essential part of the interaction between machines and human beings, and as an important part the implementation of the rules and standards by which all factories will be governed, in order to achieve necessary communication between them in terms of new information technologies.

In Colombia, according to the Minister of Information Technology and Communications (MinTic), the mining-energy boom of recent years has passed, to exploit the digital domain thanks to the use of the internet as one of the main inputs of the production, which contrasts with the report of Bank of the Republic [2], which indicates that 1106 million transactions are made monthly in urban areas and, of these, only 23 million is carried out by electronic means, to say that, currently in the

country, only 2% of the total payments are made by the mentioned means, thanks to the fact that these do not have the perception of being faster and safer within the population; also the penetration of Information Technologies in the country is low if one takes into account the easiness that are counted on at present, since until 2014, only 44% of houses had at least one computer and only 38% have an internet connection [9]. This gives an idea of the delay that the state has in the policies and regulations that promotes, generates and favors the development and implementation of new technologies in everyday life and in the operation of factories.

METHODOLOGY

In general terms, this paper makes a series of recommendations based on the review of academic literature, reports from government entities and European frames of reference on Smart Factory, in which some factors and essential aspects about the factory of the future were identified, some of them are: Internet of Things (IoT), Robotics, Infrastructures based on the cloud and Analysis of data, among others, which are elementary according to the literature, legislation and current research. In order to provide and present detailed recommendations that influence the performance of Industry 4.0, the next protocol is followed: (1) designation of the thematic area; (2) problem statement; (3) determination of guidelines for information inquiry; (4) classification of appointments and studies; (5) analysis and study of the possible execution of the established recommendations; (6) Inclusion of information with discovered data and synthesis of same.

RESULTS AND DISCUSSION

COLOMBIA TODAY

According to the World Economic Forum, in its Global Competitiveness Report 2017-2018, Colombia ranks 73th in innovation and 64th in business sophistication with a score of 3.27 and 4.07 respectively, with a total average of 3.67, in the ranking of factors of innovation and sophistication, in which 137 different countries are studied, occupying in Latin America and South America the seventh and second place respectively; which shows the opportunity for improvement in these aspects. [11]

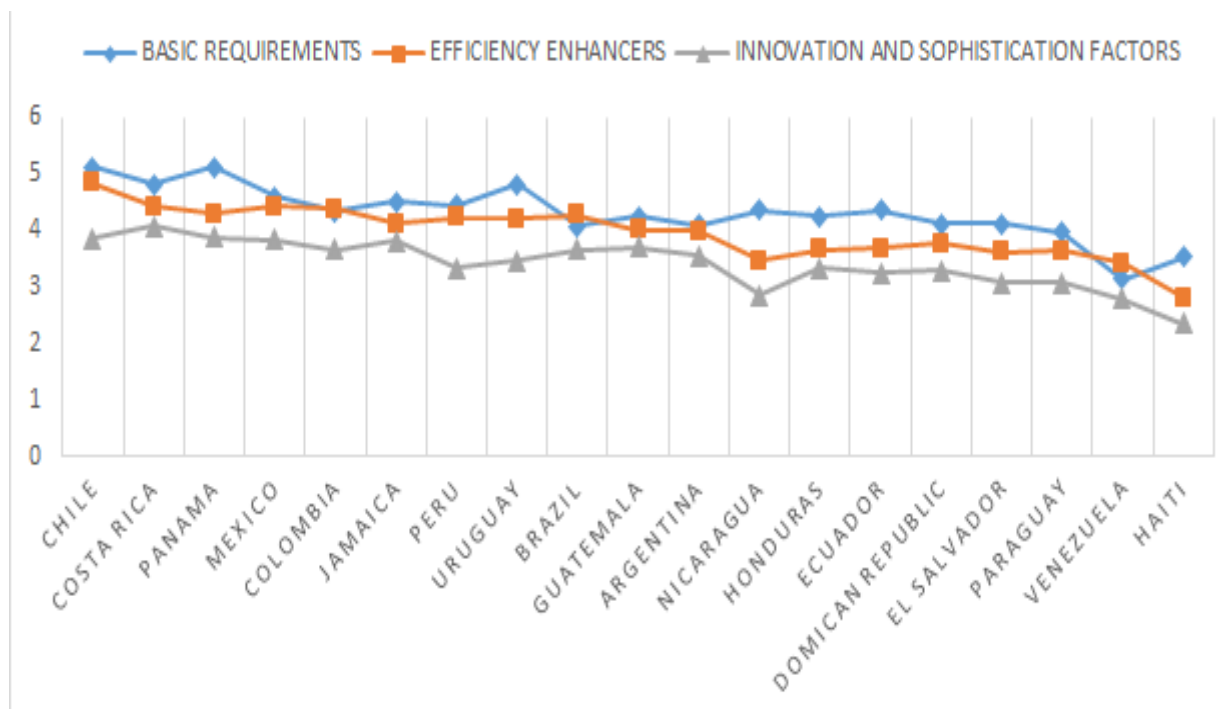


Figure 1: Latin Competitiveness Index 2017-2018[11]

The factor of innovation and sophistication, is accompanied by two important factors to be taken into account to be fully competitive, as they are:

- Basic requirements, which include: institutions, infrastructure, macroeconomic environment, health and education.
- Efficiency enhancers, which include: higher education, market efficiency (labor, goods), financial development, technological preparation and market size in general.

The continent today has an average rating of innovation and sophistication of 3.41, and although Colombia is currently considerably above, with a score of 3.67, the country should strive and continue investing as much or more as the immediately preceding years, with the objective of growing in innovation and basic requirements and strengthening in fields such as business sophistication and efficiency enhancers, where it currently stands out.

In the Fig. 1 it is shown the behavior of the country and other Latin American nations, in the three main aspects already mentioned.

While it is true, the three aspects are closely related, it is observed that in the study carried out the countries obtained a much lower score in the field of innovation regarding the basic requirements and efficiency enhancers, being a behavior not only in Colombia, but also in the continent in general.

As it has been observed, one of the country's weaknesses lies in the field of innovation, so that the country is currently interested in investing in innovation, development of information and communication technologies, fundamental for the competitiveness and development of the industry in Colombia. Despite the current economic crisis, for 2015, about 615 million dollars were invested in research and development, which compared to 2011, where investment approached 462 million dollars, has increased 24.8% in the last 4 years, of which 52.9% comes from the public sector, 44.8% from the private sector, and 2.3% from the international sector [9].

According to the above, the penetration of the use of information and communication technologies has increased proportionally to the investment made, both in Bogotá and in Colombia, see Fig. 2.

Although it is true, in Bogota the penetration of these technologies is greater, the increase in Colombia was 4.3% proportional to Bogota's. In addition, 95.6% of households in Colombia have at least one cell phone, considerably increasing the amount regarding previous years [10] which allows to see, little by little, the new technologies permeating Colombian society, starting to venture into these from the domestic level and giving a beginning for the economic and industrial apparatus of the country so it gradually enter in the new dynamics related to innovation, sophistication and technological development that are currently carried out internationally.

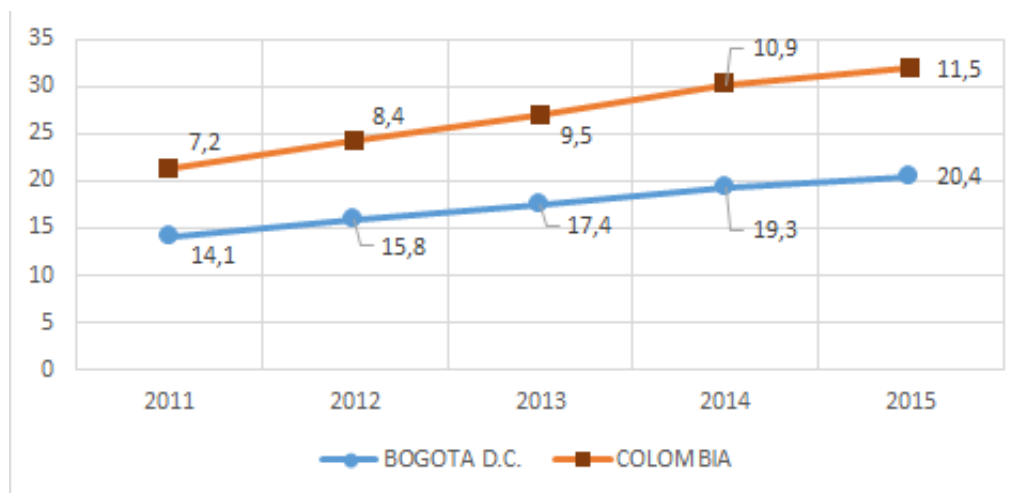


Figure 2: Index of Internet penetration dedicated [9]

CHALLENGES FOR THE FACTORY OF THE FUTURE IN COLOMBIA

Currently in the international arena, it is observed that the private business sector of the member countries of the Organization for Economic Cooperation and Development (OECD), is made, at least between 65% and 75% of investments in research, innovation and development. In Colombia, this figure reaches approximately 30%, meaning, less than this percentage of factories innovate [14]. It is a long way for the country to excel in these aspects, since it is distant from the OECD. However, this path can be reduced, making efficient use of the following tools:

- Partnerships for Innovation. Support to factories in the regions for the initiation in Innovation.
- EBT Program. Conversion of business ideas into Technology-Based Factories.
- Innovation Management. Implementation of Technology-based Innovation processes.
- OTRI's (*Oficina de Transferencia de los Resultados de la Investigación*). Promotion of the OTRI's to the market.
- Tax Benefits. Promotion of private investment in CTI (*ciencia, tecnología e innovación*).

The country must rely on these tools, since it is expected that by 2025, Colombia will be able to meet the following challenges [14]:

- Ambitious scientific production with focus, management and discipline
- More sophisticated and innovative factories
- Strengthen the Culture that values and manages knowledge

Another of the most important challenges in the country is the growth in competitiveness, where there is an improvement in

health, primary education, in the labor market and goods and technological preparation, in which it was increased by 5 positions, compared to previous years [15]. But likewise, in the aspect of innovation and sophistication, Colombia does not manage to get up, on the contrary, there was a decline of 2 positions, due to the indicators of government acquisition of high technology products and factories' spending on Innovation and Development, which fell 12 and 5 positions respectively.

The Fourth Industrial Revolution, which is developing in the world, traces new challenges and demands [15]:

- Update and permanent technological transformation
- Cybersecurity
- Development of new skills "STEM + EA" (science, technology, engineering, mathematics, English and arts).

In Fig. 3 it is shown the percentage of factories that finally opt for a digital transformation update strategy.

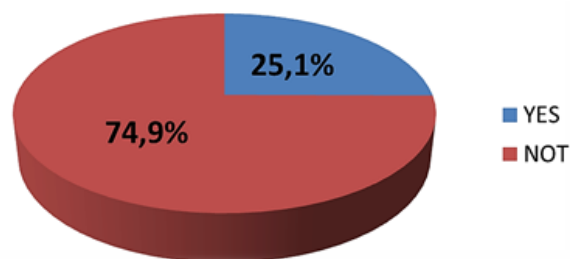


Figure 3: Percentage of factories that opt for a digital transformation and update strategy. [15]

The outlook is positive, because although 74.9% of entrepreneurs still do not have a deep knowledge of the subject,

56.3% think that it is important to start using digital technologies. Just over a quarter of entrepreneurs are beginning to adopt digital transformation strategies.

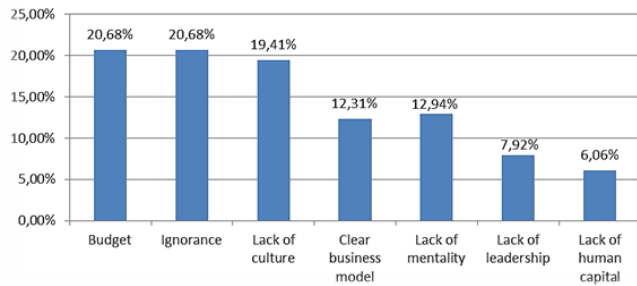


Figure 4: A successful digital transformation. [15]

Another of the main challenges that the country faces to develop and innovate in terms of its technologies are [3]:

- Small and micro enterprises represent 68% of the business population, which constitutes an economic limitation and a projection for innovation and development.
- Improve coordination between central and regional government entities regarding the management of limitations in innovation and industry development at the national level.

RECOMMENDATIONS

According to the study carried out, which identifies the failures that exist in the industrial sector, at the level of the production lines, recommendations are given regarding the following aspects:

1. Internet of Things IoT and Machine-to-Machine Communication M2M: the interconnection of devices, machines, sensors and interaction, both with each other and with who controls them, is an essential part in the production lines of the future, therefore it is recommended [4]:

- Through intelligent devices and communication between them, the data, analysis and feedback necessary for the management of control systems must be provided at each stage of the manufacturing process.
- Exploit the full potential of the analysis of information collected, through devices (sensors, transducers, etcetera), to increase the solutions given thanks to the Internet of Things in the different control systems in the production process.
- Provide, between the different devices of the production lines, an interconnection by means of which a dynamic configuration of the different control systems is reached to adapt to the changes that occur during the manufacturing process.

It is necessary to have, in the factories of the future, security systems by means of which the confidence and the assurance of the productive systems that are handled within these can be maintained and, in the case of the production lines, that they maintain only for the factory the data collected on the planning of production and in the same way the forecast of demand; for this the following guidelines are given [6]:

- Collect information about past incidents and with it perform a risk analysis to detect and prevent future events that affect the operation of the production line.
- Create security measures such as mitigation plans that minimize the effects of incidents, if they happen, in the production process.
- Take necessary measures at the time, such as the isolation of an affected subsystem or the emergency stop of a production line.
- Take into account data analysis, to create a production plan that is adapted to the capabilities of each machine or work station that is counted in the process, which must be flexible, in its execution, to be able to adjust to changes that occur in real time.

2. Human Talent: another important aspect, which will intervene and interact with the different systems within the production lines is the human component, who will receive and interpret the information provided by the different intelligent devices, therefore the following recommendations are given [5]:

- To have as analytical professional collaborators which extract and prepare the information, using it for the different statistical processes and analysis thereof, capable of constructing models that are applicable to the control systems.
- Have capable professionals with a clear intention to better use information and analysis within their work and prepared to work together with each other and with information systems.
- Prepare the staff professionally, both in cooperation and physical and virtual intervention, with robotic systems, information, etcetera, present in the factory of the future [12].

3. Infrastructure and middleware of applications based on the cloud: According to the European Virtual Learning Platform of Electrical Engineering and Computing [8], cloud computing refers to the provision of computer resources through the Internet, which guarantees storage of consistent data through the use of hardware/software distributed virtually, in order to run commercial or domestic applications.

They can be shared among a large number of users, who can access applications and data from anywhere and at any time.

About infrastructure and information processing factories or factories of the future must take actions within their production processes such as:

- The transfer of data from the edge of the network of the production lines, must keep in mind the communication variability of the device, since this depends on the frequency of batches of information.
- The transfer channels must be stable and be constantly available, avoiding intermittent interruptions as much as possible, in order to transmit the data in a timely manner to the processing systems.
- Information storage platforms must have the capacity to process large volumes of historical data by responding instantly to the incoming flows of the production system.
- It is not necessarily a requirement to make a very large investment for the factory of the future, since according to the established financial model, an efficient necessary structure can be achieved [7].
- Currently, factories can lean with models that can alleviate the cost or initial investment, such as: total financing, joint ventures and PPPs (Public-Private Partnerships), taking into account the rate of return on investment.
- Cover any type of service based on the cloud, for easy access by consumers through software applications, in order to expand and publicize its range of services.
- In the cloud, virtual machines reduce the large investment in servers of huge sizes, which in many cases remain inactive for much of the time.

4. Robotics: according to the American Society for Quality [13] in a study of the year 2013, which had as object of research several organizations in different countries, 82% of factories that implement intelligent manufacturing systems have increased its efficiency and productivity, 52% of these saw increased customer satisfaction, while 56% reported a decrease in the defects of their products. These data give an idea of the advantages that any corporation will have when they combine their operations with technology, and this, being more and more sophisticated, will increase, both in quality and quantity, the benefits that, today, have within the industry. Regarding the combination of robotics with human intervention in a production process, these recommendations are given:

- The human-robot collaboration must combine the flexibility of the human being with the high precision, strength, performance and productivity of the robots.
- Be able to handle and process products, between robots and a human operator, in order to find the most effective combination of the agility and reliability of a robotic system

with the flexibility of the workforce.

- A robot must have the ability to connect to the productive environment to which it is related, in order to adapt more easily to unexpected changes in the production it executes, both individually and in collaboration with other systems.

5. Data Analysis: Regarding the analysis of information and the emerging technologies of the Internet of Things (IoT), new options are opened for methods of analysis and visual representation, which is why the following recommendations are made [4]:

- It must have an infrastructure with the ability to maintain databases with a large amount of information, which, based on intelligent and automatic algorithms, have a search pattern rule that identifies the subset of data at the indicated time, with the objective of storing the information, among all the generated base, from any device, equipment or operation.
- By means of an appropriate model of patterns, ideas about the current and future operation can be developed, since according to which data is received from the device, forecasts and projections can be created, in order to optimize business processes.
- Databases are currently closely related to IoT technology, supporting and reducing some deficiencies in the business processes of this, providing information, whether commercial or operational at high speeds, to achieve a thorough analysis of the IoT, without restrictions in volume, type or relevance of the data, since it is considered that the most recent data are more valuable than the old ones.
- It is characteristic, in data analysis, that event stream processes (ESP) and complex event processes (CEP) are included, since normally in the IoT data, they include some type of event that can be related and correlate several events in the business context.

CONCLUSION

The Colombian industry, at present, is entering the development and technological innovation applied to the production lines and in general to all the related processes, therefore, policies or programs must be developed in conjunction with the governmental sector for the decrease in the backwardness that the country has in this aspect, which in the future, will be increasingly essential in the national and international economy.

Currently, the main aspects and challenges required to be a competitive or innovative country were evident, in which the country has not developed sufficiently as other Latin, European or Asian countries. Based on the current context and outlook, suitable tools are presented to study, analyze and finally

develop the exposed challenges, in order to project a country that is more competitive, innovative and sustainable.

This paper identified some of the main aspects to be taken into account so that, once the incursion into the Industry of the Future is achieved, an adequate implementation and management of it is achieved so this way greater benefits can be obtained thanks to the use of new technologies that support and improve production processes.

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