THE PATHWAYS FOR BRAZILIAN COMPANIES

TOWARDS THE FOURTH INDUSTRIAL REVOLUTION: The So-Called "Industry 4.0"

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NOVEMBER / 2019

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PRESENTATION
Proposal of Technical Article in compliance with the Master's degree in Mechanical Engineering, in the discipline of Methodology of Scientific Research for the Professional Masters of Mechanical Engineering course, Department of Mechanical Engineering, University of Taubaté.
Abstract: In Industry 4.0 the interconnection of digital and real worlds is the main feature, there will be a massive growth in the use of digital technologies and an exponential growth in data generation. Production will be vertically connected with the processes that make up the business and horizontally connected to the value chains. It is not only competition that is demanding changes in manufacturing, the product life cycle is shrinking, and the demands for tailor-made production are increasing, migrating from mass production to mass customization of physical objects with the ability to communicate with the internet. Human beings assume a new role, as a creative element and resource manager, so human capital is key to the transformation that is intended, the lack of digital skills is certainly a more significant barrier that can prevent Brazil from implementing Industry 4.0. Flexibility, Quality and Time for Marketing are the demands of Industry 4.0. The aim of the research is to help companies position themselves in the "Industry 4.0" journey, understanding the lack of technological knowledge and how the internal and external environment of companies can promote the conditions for the new wave of creative development that will come. Brazilian industries have prioritized improving the production process, increasing productivity, but the focus should be expanded on the digitization effort advocated in the manufacturing of Industry 4.0. Companies seeking to adapt their processes and equipment to the "Intelligent Factory" needed to make the most of the opportunities presented by Industry 4.0 should be thought of as a five-step process as a way to help provide the guidelines that need to be followed and processes that they need to adopt to thrive in a connected world: to establish technological quality partnerships, ability of equipment to connect with each other, engage in team qualification, the ability to analyse data, and develop learning for decision-making with a view to business strategy. Being prepared for the 4th Industrial Revolution is imperative for our competitiveness.

Keywords: Industry 4.0, digital, manufacturing, production, companies
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### List of Acronyms

3D – Third dimension

ABDI - Brazilian Industrial Development Agency (in portuguese)

BMW - Bayerische Motoren Werke

B2B - Business to Business

B2C – Business to Commerce

BNDES – National Development Bank (in portuguese)

BOM - Bill of Material

CAD - Computed Aided Design

CAM – Computer Aided Manufacturing

CNC - Computer Numerical Command (in Portuguese)

CIESP - Centre of Industries of the State of São Paulo (in Portuguese)

CNI - National Confederation of Industry (in Portuguese)

ERP - Enterprise Resource Planning

FIESP - Federation of Industries of the State of São Paulo (in Portuguese)

G-CODE - Programming Language for Industrial Machinery

GDP - Gross Domestic Product

IIOT - Industrial Internet of Things

IMIs - Integrated Micro-Electronics

IoT – Internet of Things

i 3 – BMW Car Model

M.E.S - Manufacturing Execution System

MIT - Massachusetts Institute of Technology

MTBF - Mean Time Between Failures

MTTR - Mean Time to Repair


OEE - Overall Equipment Effectiveness

PD&I – Research, Development and Innovation

PLC – Programmable Logic Controller

PROFINET - Process Field Net

RFiD - Radio-Frequency Identification

SCADA - Supervisory Control and Data Acquisition

SENAI-SP – National Service of Industrial Learning – São Paulo (in portuguese)

SWOT – Strengths, Weaknesses, Opportunities, Threats
IT - Information Technology (in portuguese)
ICT - Information and Communication Technologies
WIP - Work in Process

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1. Introduction

1.1 Contextualization

For some time, the interconnection between the digital and real worlds has become fact. We use our smartphones to find out, in real time, if a plane is late. At home, we track the orders we're expecting in just a few clicks.

In Industry 4.0 the interconnection of digital and real worlds is the main characteristic, the development of new products, processes and services from the integration of technologies such as robotics, augmented reality, internet of things, "big data", intelligent sensors, artificial intelligence, additive manufacturing, among others. There will be a massive growth in the use of these technologies and an exponential growth in the generation of statistical data that will reinforce the disruptive character of the 4th Industrial Revolution.

As a result, production will be vertically connected to the business process and horizontally connected to geographically dispersed value chains that can be managed in real time. In this way, production processes tend to become increasingly efficient, autonomous and customizable: by connecting machines, systems and assets, companies can create intelligent networks along the entire value chain.

All areas will be impacted, the factory floor, the top management of the companies, the entire value chain, the demand profile and the nature of the products.

“The focus (of Brazilian industries) has been to improve the production process, increasing productivity. This is a positive but limited focus, since it leaves opportunities open at the stage of development of the productive chain and in the exploration of new business models. Brazilian industry is following a path that seems natural: at the beginning, it focuses on increasing efficiency, and then moves towards applications more focused on the development of new products and new business models. However, considering the competitive position of Brazil in the global economy, the most recommended would be that the effort of digitization would be carried out simultaneously in all dimensions”. (CNI, 2016)

Investment, availability of financing and human capital are pillars for the development of Industry 4.0.

1.2 Definition of the Problem

Today we have Brazilian companies in the Industry 3.0 phase or midway towards
the 4th Industrial Revolution, which will require adaptation or the framework for a future vision of Industry 4.0.

One factor is essential for the future economic success of Industry 4.0, Brazil should not only adopt the Fourth Industrial Revolution, it must also contribute innovation to its definition and construction. And innovation requires a pedagogy, requires people, requires talent training, we cannot buy it, people have to be motivated. It requires that the attitudes of entities be compatible with what we want to achieve.

The big question is to understand how our human capital is prepared to build this path of development, creativity and advancement. How our institutions understand their role in training people, and how our companies understand and are willing to take that leap of innovation in digital technology.

1.3 Research Objective and Characteristics

The research explored in the first place the discussions around the theme in the 1st Brazilian Congress of Industry 4.0 "The Impacts and Challenges of the 4th Industrial Revolution" promoted by FIESP in December 2017, and it was intended to define a direction for research to conduct bibliographical surveys and analyses of examples that stimulated understanding. The research approach methodology should be qualitative using as a research method - action.

The research intends to be applied, the product aims to help companies position themselves in the "Industry 4.0" trajectory, understanding the lag of technological knowledge and how the internal and external environment of companies can promote the conditions for the new wave of creative development to come.

This network of devices for access, people and information systems is preparing us for the "internet of things", an already popular topic under discussion. An increase in interconnectivity will not only affect our personal lives, information technology will also lead to permanent changes for industry. Therefore, being prepared for the 4th Industrial Revolution is essential for our competitiveness.

2. Theoretical Rationale

As the state-of-the-art is an important and crucial part for a correct development of the article, the truth is that as the subject is very recent, information is immensely scarce. To develop the article in such a premature state of the industrial revolution precludes extensive and abundant research.


2.1 History, from Industry 1.0 to Industry 3.0

A few years ago we talked about the term Industry 4.0 and how it will shape Industry in the Future. We have many reports that tell us about companies in Germany (where the term started), and other developed countries in Europe that are applying technologies in their production system and implanting a new Industrial Revolution. Let's look at the characteristics of Industry 1.0, 2.0 and 3.0.

2.1.1 First Industrial Revolution - Industry 1.0

This revolution was characterized by two important inventions that proposed a turnaround in the productive and transport sector, science discovered the usefulness of coal as a source of energy and from there developed the steam engine and the locomotive. Both were decisive in order to stimulate the transport of raw materials, people and distribution of goods, giving a new panorama to the means of getting around and producing.

The first industrial revolution occurred in the eighteenth and nineteenth centuries, with the beginning of the use of coal as an energy matrix, replacing hand-crafted production with mechanized production processes. (CARMONA, 2017).

With the progressive substitution of artisanal methods of production, changes in production processes had significant economic and social consequences. The artisan, who until then controlled the whole production process, from the exploitation of the raw material to the final product, went to work for a boss who controlled the process, the raw material, the final product and the profits (ZARTE et al, 2016).

The use of machines in industry, which performed with great strength and agility due to coal-based energy, provided an extremely dynamic productivity, with which industry became an alternative of work, at the time that thousands of people left the countryside for the cities.

One of the first areas to enjoy this benefit was textile production, which, prior to the revolution, was handmade. This new model accelerated the rural exodus, thus causing the growth of urban centres. (AZEVEDO, 2017). Soon, several sectors decided to use this means of "process automation" and inserted machines into their production systems.

Science has entered a constant process of evolution. This process has triggered a number of new technologies that have rapidly transformed human life, above all, in the way goods are produced. In this case, it served mainly the industrial sector, accelerating
the development of the capitalist system.

The first revolution in production methods, known as the Industrial Revolution, took place in England. Soon other countries such as France, Belgium, Holland, Russia, Germany and the United States entered this new model of industrial production.

"Industry 1.0 is then marked by the introduction of machines in industry to automate processes, until then 100% handmade".

2.1.2 Second Industrial Revolution - Industry 2.0

During the unfolding of the Industrial Revolution it was realized that the growing need for new technologies became a common demand for any nation or industrial owner who wanted to increase their profits. With this, the industrial model stipulated in the eighteenth century underwent several changes and improvements that marked this constant search for novelties.

The second industrial revolution occurred in the middle of the nineteenth century, when electricity became the main source of energy in factories, allowing for the great development of the oil and steel industries. (CARMONA, 2017).

Several scientists began to work on theories and machines that could reduce the costs and time of manufacturing of products that could be consumed on ever-increasing scales.

In the decades that followed and until the end of World War II (1945), developments were significant in the chemical, electrical and steel industry, as well as a significant improvement of existing techniques. The first steel boats appeared driven by powerful steam engines, revolutionizing the transport of goods. There were also the first production lines that would allow mass production and low costs. Invention and innovation developed together in this, which was the second Industrial Revolution. (COSTA, 2017).

The use of such resources, fossil energy and electromagnetism, propelled the acceleration of industrial rhythm, thus discovering the potential to reduce both the costs and the time of product manufacturing, which could be consumed on an increasing scale. One of the most obvious examples of this revolution is the introduction of the assembly line, with the Ford T as a traditional reference. (AZEVEDO, 2017)

This period also gave rise to Fordism, a term created by Henry Ford in 1914, which refers to mass production and management systems. It is a form of rationalization of capitalist production based on technical and organizational innovations that are
coordinated in view of mass production on the one hand and mass consumption on the other. He strictly followed the principles of standardization and simplification of Frederick Taylor and developed other techniques advanced for the time. Their factories were fully verticalized. He had everything from the glass factory, the rubber plantation, to the steel mill. This set of changes in work processes (semi-automation and assembly lines) is closely linked to new forms of social consumption.

Through these innovations, industries were able to achieve ever greater profits and streamline the process that took place between obtaining the raw material and selling the product to the final consumer. At the same time, the more specific control over expenses allowed the precise calculation of the profit margins to be obtained with a particular industrial item. In this way, capitalism broke new frontiers and directly affected the acceleration of the world economy. In this period the United States, Germany, Japan and France have become global leaders of Technology.

Industry 2.0 is then marked by the improvement and refinement of First Revolution technologies for large-scale production, the use of new energy sources such as oil and electricity as well as the creation of automated production lines and the advent of the automobile and arms industries.

### 2.1.3 Third Industrial Revolution - Industry 3.0

The Third Industrial Revolution, also known as Technical-Scientific and Informational Revolution, is a process of technological innovation marked by advances in the field of Informatics, Robotics, Telecommunications, Transportation, Biotechnology and Fine Chemistry, as well as Nanotechnology.

The third revolution occurred at the end of the twentieth century, with advances in information technology and the introduction of microprocessors and increasingly technological processes in all industrial segments. (CARMONA, 2017).

In the 1950s and 1970s, we began designing what was to be considered the third Industrial Revolution, the digital revolution, with the proliferation and use of semiconductors, computers, automation and robotization in production lines, with stored information and digitally processed, communications, mobile phones and the internet. (COSTA, 2017).

The Technical-Scientific and Informational Revolution is also characterized by a profound change in the modes of production adopted by the big corporations in the world. Before, the Taylorist / Fordist model was predominant, characterized by mass production
of commodities.

Currently, what is in vogue is the Toyotista model, where production is flexibilized according to demand, which requires better technology and, obviously, a smaller number of workers, who must be increasingly able to operate increasingly complex and sophisticated production systems.

Another important aspect is industrial decentralization. This is because innovations in communication and transportation techniques (such as the internet and jet aircraft) allow industries to migrate to any advantageous region where they find abundant raw materials, cheaper labour, less efficient environmental laws and a larger consumer market. This marks the basis for the expansion of multinationals, although the emergence of these occurred before the Third Industrial Revolution.

It is important to know that the technologies in each of these sectors are essential for the advances in the others, with a close interdependence between their forms of application.

The third Industrial Revolution was known through the intensive use of electronics and Information Technology (IT) to achieve the goal of manufacturing automation. In the industrial area, the Supervisory Control and Data Acquisition (SCADA) systems, in conjunction with the PLC, constitute their largest exponent, and such systems currently converge to open systems and, in some cases connected to the corporate network or even to the internet. (AZEVEDO, 2017).

In capitalist societies, especially in the most industrialized ones, the creation of highly sophisticated technologies improves the performance and the productivity of work, creating products of better quality and reducing the production costs of companies. The dissemination of telephony services by ocean cables or by satellite, the computerization of companies and the transmission of data over the Internet allow, for example, simultaneous integration between the headquarters of industries, banks and stock exchanges around the world. The mass transportation of people and goods by ships and large aircraft has made business and international trade much more intense.

The process of the Third Industrial Revolution, which was unleashed in the last decades of the twentieth century, was decisive in consolidating the present phase of capitalism and the international division of labor, the so-called globalization.

2.2 The New Concepts of Consumption

"It's not just competition and cost increases that are demanding changes in
manufacturing," says Siegfried Russwurm, world president of Siemens' industrial division. "The technology lifecycle is narrowing and the demands for tailor-made production are increasing." (COSTA, 2014).

The product lifecycle is geared to the growing desire for customer customization and encompasses everything from the original concept to ordering, developing, manufacturing, delivering to the end customer and recycling, as well as all associated services. (ANDERL, 2017).

Manufacturing is no longer simply about the production of physical products. Changes in consumer demand, the nature of products, the economy of production, and the supply chain economy have led to a fundamental change in the way companies do business. Customers require personalization and customization as the line between consumer and creator continues to decline. (CHEN, 2017).

In fact, as observed in Graph 1, since the First Industrial Revolution a reduction in the diversity of products and an increase in the volume of production, a combination called mass production, has been observed until the mid-1950s. When we then reverse the curve with what we are calling the Fourth Industrial Revolution, we arrive at the regionalization of production.

As an example of the use of the technology facing the need to speed up the launch of a new product by reducing the life cycle, Toyota, Fiat and Nissan automobile
Manufacturers have reduced the new model development time by up to 50% from the time that designers and engineers began to use digitized information and virtual parts testing. (Costa, 2014).

Meanwhile, the frontier that separates product manufacturers from product sellers is increasingly permeable. Manufacturers are feeling the pressure to gain skill-increasing speed for the market and customer involvement. And several factors are driving manufacturers to manufacture to order instead of build to stock. (Chen, 2017).

As shown by José Borges Frias Junior in Fig. 1, representative of German manufacturer Siemens in the 1st Brazilian Congress of Industry 4.0 Fiesp, Efficiency, Flexibility, Quality and Time to Commercialization are the industrial demands in the era of the Fourth Industrial Revolution.

![Image: Technology is the solution to main challenges and drivers in the industrial environment](image_url)

Figure 1. Siemens Brazil, José Borges Frias Junior - 1st Brazilian Congress of Industry 4.0 Fiesp

At the same time, as products become less value objects in their own right, and more the means to access information and experiences, the creation and capture of value went from the delivery of physical objects to enabling such access. (Chen, 2017).

As an extreme example of minimizing the design time of a new product until the sale to the consumer we have the Adidas pop-up shop that worked in the first quarter of 2017 in Berlin, the customer participates in the design and accompanies the manufacture of its product "in loco" and in real time. It brings to the market a new possible paradigm.
of production and questions the traditional view of how work and the means of production are organized. That is, a process that traditionally in the fashion industry takes more than a year between design, production, distribution logistics and sales, is replaced by tens of minutes. Product development teams change from paper, retail changes its configuration, the "production function" almost disappears as we know it. (CARVALHINHA, 2017).

In Fig. 2 Byoung-Gyu Yu observes the change from the Production-Consumption cycle; in the past we had a sequential process and in the era of Industry 4.0 we have a process that is both integrated and interdependent.

II. Production & Consumption in the 4IR Era

The production-consumption cycle is shifting from a sequential process to an integrated, interdependent process

Figure 2. Korea Institute for Industrial Economics and trade (KIET), Byoung-Gyu Yu - 1st Brazilian Congress of Industry 4.0 Fiesp

As the manufacturing landscape evolves and competitive pressure increases, fuelled by increasingly demanding customer needs, the position will be more important than ever. In all decisions about where and how to play in this new environment, there is no master manual - and no single path to success. But by understanding these changes, functions, and points of influence, both operators and new entrants can use the tools to
navigate successfully in the new manufacturing landscape. (CHEN, 2017).

2.3 The Emergence of the Term Industry

At the beginning of the 21st century, with the development of the Internet, increasingly smaller and more powerful sensors, increasingly affordable prices, increasingly sophisticated software and hardware, the ability of machines to learn and collaborate by creating giant networks of "things" (IoT - Internet of Things), a transformation has begun in industry, whose impact on competitiveness, society and economy will be such that it will transform the world as we know it. This transformation was nicknamed by Erik Brynjolfsson and Andrew McAfee's professors at the Massachusetts Institute of Technology as the second age of the machine and in 2011 at the Hannover Industrial Fair in Germany the term Industry 4.0 was spoken (DREHER, 2016) upud (COSTA, 2017).

This revolution was born out of 4 distinct pilots that propelled the transition from the 3rd to the 4th revolution (of greater digitalization of the manufacturing industry), namely: Drastic and rapid increase in data volume; power of computing and connectivity; The advancement of analytical capabilities; The introduction of the new form of human interactions and machines; Innovations facilitating the transfer of digital data to something physically usable; (BORLID, 2017).

Based on data taken from renowned abstracts and citation databases in peer-reviewed literature, journals, books and articles, it shows the evolution in the number of publications in general within the databases studied from 2011 onwards with the theme, which was the year in which the term Industry 4.0 was officially introduced by the German government, peaking in 2017. Chart 02 (CARMONA, 2017).
Graph 02. Evolution of number of publications in databases (CARMONA, 2017)

CARMONA (2017) states that it is not possible to state the real reason for the increase in the number of publications related to Industry 4.0, but some inferences can be made:

- Dissemination of the topic within universities, because it is directly linked to scientific and technological innovation;
- Amplitude of the impacts generated by the theme, being able to cover all sectors of the economy as well as several areas of study;
- The need for the market and educational institutions to be able to understand the impacts generated by the theme.

The term describes a new step in the organization and management of the entire value chain throughout a product's life cycle. (ANDERL, 2017).

The term industry 4.0, therefore, arose from the massive increase in the use of the transforming technologies in industry, mainly IoT (Internet of Things). The evolution as it has been studied shows how much the transformations will modify the world as we know it.

2.4 What is industry 4.0, the Fourth Industrial Revolution

For McAfee and Brynjolfsson (MIT Teachers), who had a talk in June (2014) with US President Barack Obama to discuss the issue of competitiveness, the global productive
sector is in a process driven by three forces: the exponential advance of computing capacity, the vast amount of digitized information and new strategies for innovation. (COSTA, 2014)

The real-time network of products, processes and infrastructure is ushering in the fourth industrial revolution in which supply, manufacturing, maintenance, delivery and customer service are all connected via the Internet. (ANDERL, 2017).

Product conception, design, testing with new materials, prototypes, factory architecture, production line organization, stocking of materials, equipment manuals, everything is digital. (COSTA, 2014).

The Fourth Industrial Revolution will transform the way we organize around the current productive model, everything we believe and place our initiatives in recent decades as being the most advanced and creative way of producing will be profoundly changed to a new level of technological utilization, represented by the increasing amount of digitized information.

Perhaps the key word of this century is digitization. Digitization is present in all spheres of human activity. When it comes to business activities, digitization is an embodiment of the Industry 4.0 concept. That is, words such as mechanization, electrification and computerization are key words for the first three industrial revolutions, respectively, as well as digitization, which includes the use of integrated cyber-physical systems, a key word for the fourth industrial revolution or Industry 4.0. (MASLARIĆ, 2016).

The Fourth Industrial Revolution is unlike anything humanity has ever experienced. New technologies are merging the physical, digital, and biological worlds to create great promises and possible dangers. The speed, breadth, and depth of this revolution are forcing us to rethink how countries develop, how organizations create value, and what it means to be human. (SCWAB-2016)

This revolution is causing profound changes, not only in industry, but also in society, in economy, in values, in the way we relate, in how we choose products and services, in shared economy, in collaborative innovation, in additive manufacturing, in social networks and digital platforms, among others. (COSTA, 2017)

Industry 4.0 is not only about the digital age and process improvement, it is also about developing new ways of working, new business. It is an internet-driven revolution where the digitization will reach all kinds of industries and will be the basis for the future of competitiveness.
The transformation that consumer models are going through, migrating from mass production to the mass customization of physical objects with the ability to communicate with the internet, sending and receiving data is possible.

Customers require personalization and customization as the line between consumer and creator continues to decline. Added sensors and connectivity transform "dumb" products into "smart" products, while products become more and more platforms - and even move into the service field. (CHEN, 2017)

Highly intelligent products with the ability to communicate with the value chain will require intelligent factories.

In this view, factories will be much more intelligent, flexible, dynamic and agile. Another definition for "Smart factory" is a factory that makes intelligent products, in smart equipment, in intelligent supply chains (HUBA et al, 2016) upud (COSTA, 2017).

The fourth industrial revolution, sometimes referred to as Industry 4.0, will allow the computerization of machinery and automation using robotics, as well as the interconnection of various machines allowing communication between them. It will enable intelligent measurement and analysis of data to improve efficiency, cost-effectiveness and safety. The fourth industrial revolution will create a wave of innovation in areas such as the automotive industry, the creation of parts in 3D printers that allow the maintenance of machines with pieces created to order, or even remotely and on request, robotics with artificial intelligence, the optimization of the transport industry with the use of lighter and more resistant materials, and many other applications. (SANTOS, 2017).

Digitization will make the production process much more agile and dynamic, with machines communicating with each other, forming a network within the value chain. Measuring and intelligent process controls will provide significant productivity gains. As estimated by McKinsey Consulting in Fig 3.

On the other hand, the benefits of adopting new technologies are clearly identified: improvement in product and communication quality, time and cost savings, and improvement in customer / consumer relations (Oesterreich and Teuteberg, 2016) upud (ANTUNES, 2017).

The incorporation of digital into industrial companies has an impact on value chains both locally and globally (Deloitte, 2015). Through this technology, the cost of production can be reduced and companies are able to deliver customized products / services more efficiently. (ANTUNES, 2017).
The fourth industrial revolution will only be possible in fully integrated and intelligent environments, where the boundaries between industry and services and between different sectors are becoming smaller and smaller. (ANTUNES, 2017)

The main features of Industry 4.0 are its ability to enable intelligent people and factories to connect and exchange information through the Internet of Things and Services Internet, the possibility of connecting physical systems with virtual or cyber-physical models, the decentralization of decision-making and management, these being carried out in an independent way and of their ability to be adjusted to market requirements in real time (MASLARIĆ, 2016).

Industry 4.0's ability to enable intelligent people and factories to connect will only be possible in fully integrated environments.

The new forms of technology that deal with this transformation bring profound changes in all sectors of society, affecting the entire business model, production, consumption, transportation, delivery and the way people live. Therefore, it is necessary to have a comprehensive view of how this digital transformation changes in every aspect the world in which we live, in social, cultural and economic ways. (AZEVEDO, 2017).

Examples of the BMW plant in Leipzig, Philips in the Netherlands, Siemens in Amberg and Linde in Latin America take us into the physical environment of Industry
It may not produce robots, like the imaginary U.S. Robots and Mechanical Men, but on the i3 assembly line, BMW's first electric model, everything looks futuristic. There is no noise or even sparks. As if in a synchronized dance, mechanical arms lift casings, gather parts, and even do quality tests there. The automotive industry is among the most robotic in the world, but BMW's most modern unit, with its more than 1,000 robots, is still a case in point. The employees, all in blue waistcoats, follow everything from a computer screen at a distance. Humans only supervise the functioning of the machines. The Leipzig plant is a preview of the future of the factories. "We are in the early stages of such a profound change in manufacturing as that brought about by the Industrial Revolution," said Erik Brynjolfsson, professor of information technology at the Massachusetts Institute of Technology. (COSTA, 2014).

A year ago, Philips built an electric razor factory in the Netherlands with 126 robots and a few dozen people. "Jobs that involve repetitive functions will disappear quickly in the next few years," says Nobel Prize-winning economist Michael Spence and a professor at New York University. (COSTA, 2014).

In an intelligent Siemens electronics unit in Amberg, without interference from employees, machines that operate 24 hours a day manufacture 950 different components that are ordered by the system. Extreme automation leads to a very low rate of defects - a study by the American consultancy Gartner in Amberg recorded 15 defective parts per 1 million produced. (COSTA, 2014).

In the industrial gases sector, Germany's Linde has recently adopted a remote management system. From an operations centre in Jundiaí, in the interior of São Paulo, about 50 engineers operate 33 units in Latin America. This has meant that Linde's units, which once had about 20 employees each, now work with teams of three. "By concentrating all the specialists at the Jundiaí operations centre, we have increased our productivity by 30%," says Max Amilcar, director of Linde. (COSTA, 2014).
Finally, the bases of Industry 4.0 are defined, as shown in Fig. 4 of Zorfatec Consulting in Innovation, we can highlight most relevantly human beings assuming a new role, as a creative element and manager of resources, as seen in the BMW factory in Leipzig.

2.5 Which Technologies?

The objective in this work item is only to cover the technologies available and that are being used in the journey of the Fourth Industrial Revolution, citing them and giving a brief description seeking to conceptualize them in the context of Industry 4.0.

BORLIDO (2017), in his dissertation "Industry 4.0 Application to Maintenance Systems" of 2017, describes the most representative technologies of the articles that serve as the bibliographic basis for this work. The technologies are the following items from 2.5.1 to 2.5.13:

2.5.1 Industrial Internet of Things

The fourth revolution focuses on cyber-physical systems. One of the great
advances of this industrial era is the Industrial Internet of Things that allows machine-to-machine communication without human intervention.

The advantages of the Industry of Things are the development of communication between devices or machines increasing efficiency, industrial safety and reducing costs and time.

### 2.5.2 Internet of Things

This concept represents the fact that any equipment connected to the Internet can be connected to another. The term is more representative of how, in today's society, people can interact with their smartphones, smart cars, turn on/off the home heaters, check the garage door is closed, turn on the house entry lights, etc. ...

The term Internet of Things is common and necessary within the scenario of Industry 4.0, as in a simple way the term represents the ability of any physical object to communicate with the Internet, it being possible to send and receive data. IoT is expected to provide high-impact economic and logistical opportunities because of its large capacity for information exchange and self-management.

### 2.5.3 Industrial Internet of Things vs Internet of Things

This concept represents the use of the network for machines to communicate with each other with remote applications, so they can be monitored and controlled. In other words, the Industrial Internet of Things depicts all the sensors and software that allow a connection between machines.

IIOT is the use of IOT in the industrial sector. Here we can talk about various concepts such as big data, machine learning, M2M that help us understand why M.E.S and IIOT have such a promising relationship that they have everything to grow in the new industrial era. IIOT also ensures greater visibility / transparency throughout the supply chain (each pallet, box, container, vehicle, ... can be equipped with GPS systems for constant control).

It is a set of net-linked items, each embedded with sensors, and these sensors are connected to the Internet, capable of collecting information and exchanging data.

### 2.5.4 Cloud

The information is in a shared cloud. The interconnection of all products with each other made the data (information) throughout the entire supply chain difficult to store by
only one company, so the idea of using a cloud came up.

Having gigabytes of free space, stored data security, and automatic file synchronization are the major advantages of cloud services. What happens is that instead of storing locally, which would involve, for example, a greater investment in disks, it stores the information on servers and can access them from a computer or a smartphone. Virtualization is here to stay and being able to access from any location without having the data physically does not mean that the data has lost its form. One of the advantages of the cloud is that it proposes automatic synchronization that, even when offline, changing a document is replicated in the cloud in seconds. In those where synchronization is not done automatically, we call them hosting because the files are uploaded to the server by the user manually (Note that this type of cloud is more used for "archive" storage because they are files accessed sporadically).

2.5.5 Big Data Analytics

All information gathered together, dynamically for decision making. Big Data Analytics serve as a set of information (market study, market information, unknown correlations). Its main goal is to help companies make the best decisions at the right time.

2.5.6 Robotics and 3D Printing

3D printing is the most flexible type of industrialization / product design at the present time, so it fits perfectly in Industry 4.0.

Every type of programmable and editable tool that involves all innovation and that is able to flexibilize a productive process is a 4.0 tool, so it is easily understood that a robot or 3D printing are examples of this. In the new industrial era, it will make more evident the implantation of robotic solutions with less human labor needs (there are robots with human-robot interaction) and / or of solutions that due to several iterations and tests allow us to arrive at solutions (3D printing) in a more efficient and cost-effective way throughout the entire production process.

2.5.7 Digital Manufacturing

In this new industrial age, the use of increasingly developed software is felt much more clearly, so that the manufacture and digital modelling are important characteristics of the development of this industry. This process joins design and fabrication in the simple use of 3D tools or CAD (Computer Aided Design). In this part the connection between
CAD and CAM enters, that will be translated into something after translation to G-CODE (Code used in CNC's). There are several types of machines for intelligent manufacturing. Among them are the CNC, Laser Cutting and 3D printers.

2.5.8 Remote Management

This is the process that allows managers to take full control of all operations. In addition, and with special focus, it was created for someone to be able to configure, control or improve our direction.

2.5.9 Production Monitoring

Monitoring within Industry 4.0 occupies a very specific space because it is one of the points that remain, that is, control and monitoring of data follows the same philosophy as "before". The calculation of OEE, Takt Time, Downtime, among others, continues to be the future monitoring.

2.5.10 M.E.S

One of the pillars of Industry 4.0 is the implementation of a Manufacturing Execution System that is not just a planning system like an ERP. The MES has everything coordinated. In fact, we can reference several uses of it such as:

- Production of pieces;
- Switching on / off machines;
- Coordination of inventory in and out of the production line;
- Change of manufacturing orders;
- Personnel movements and hiring or firing;
- Adjust stocks by buying or using material;
- Scheduling interventions for maintenance or use of machines.

MES is a tailor-made tool for the automotive industry because it brings immense planning potential, as well as reducing cycle times, WIP, paper usage and responding to customer requests, for example.

The main features of this system are:

- Import of ERP System data such as BOM (Bill of Material), stocks,
- Import of production orders;
- Automatic issuance of instructions for delivery of the correct material on
the correct assembly line, for example;

- Storage of productive information such as operating time, machine times, scrap, ...;
- Instructions for replacement material;
- Storage and dissemination of quality data (nonconformities, special instructions derived from incidents);
- Integration of the ERP with the factory floor;
- Statistical control of the process;
- Production monitoring (stoppages, productive rhythm, reworking, etc.);
- OEE on time;
- Control of occurrences and maintenance indicators (MTBF, MTTR) (PPI-Multitask, s.d.).

Of these functionalities, we derive several advantages such as:

- Support for Lean Manufacturing;
- Support for continuous improvement;
- Reduction of lead times, setup times, planning time;
- Quality improvement;
- Reduction of stocks;
- Total transparency of data;
- Improved customer service;
- Improved employee productivity

### 2.5.11 Smart Factory Concept

An intelligent factory is a factory that works at maximum efficiency while the intelligent machines are interconnected with each other, collaborate with each other, with the workers, with the suppliers and customers and with the analytical and dynamic chain created for self-control.

It is a paradise in terms of efficiency where defects, productive breaks, waste and waiting do not exist. It is the pinnacle of technological and industrial development. The company of the future uses all the concepts explained about Industry 4.0 such as Big Data Analytics to improve processes and live with constant changes in demand, for example.
2.5.12 PROFINET Communication

Profinet (Process Field Net) is the type of industrial sector data communication by definition. It uses an Ethernet connection and monitors, for example, real-time automaton signals.

Profinet communication is a prerequisite of Industry 4.0 because data transmission and the need for increasingly restricted physical space are special conditions for the use of this communication (with Profinet instead of Profibus, we do not need cables, for example). Profinet is a link between all the Profibus expertise (Safety, Diagnostics and High Speed Communication) along with the flexibility and ease of use offered by Ethernet (faster communication rate; Wireless).

2.5.13 RFiD / Industrial Traceability

One of the most important issues at industrial level is the traceability of products that are received and produced, because the requirement and competitiveness is such that if we do not offer total trust and transparency to the customer in the products we sell, everything becomes complicated. At this point the RFiD enters.

In an increasingly competitive industry and where the minimum lapse (cost, quality, deadline) can have exponential consequences, manual traceability is not an effective or correct way of assisting production processes, in addition to greatly increasing the logistic times and it not being possible to monitor in real time.

The RFiD system is a wireless communication system that uses radiofrequency waves to identify and route objects and seamlessly integrates into the Manufacturing Execution System as it interacts with the production process from the raw material phase to the final product (tracking). RFiD can easily identify an object, where it is and in what condition, and that is one of the main reasons for being integrated into the Internet of Things.

At the level of traceability there are several types of labels, from 1D, 2D, DM or even RFiD that is better than the others mainly because it is not necessary to position it precisely for the reading device.

The ten most promising technologies according to the United States Competitiveness Council in partnership with Deloitte. Referred to in Fig. 5 and Fig. 6.
As dez tecnologias mais promissoras segundo o Conselho de Competitividade dos Estados Unidos em parceria com a Deloitte.

1. **ANÁLISE PREDITIVA**
   Utiliza uma variedade de técnicas estatísticas, matemáticas e analíticas para prever eventos futuros ou comportamentos baseados em dados passados.

2. **PRODUTOS CONECTADOS E INTELIGENTES (IOT)**
3. **FÁBRICAS INTELIGENTES (IOT)**
   Internet-of-Things (IoT) refere-se à fusão de software, sensores e conectividade de rede que permite a interação digital entre objetos e máquinas.

4. **MATERIAIS AVANÇADOS**
   Referem-se à descoberta e fabricação de novos materiais, como metais leves e de alta resistência e ligas de alta performance, cerâmicas avançadas e compósitos, materiais críticos e polímeros bio-based.

5. **DESIGN DIGITAL, SIMULAÇÃO E INTEGRAÇÃO.**
   É a conceitualização e construção digital de um protótipo virtual, ou de um processo virtual, alcançado por meio de simulação computacional de um produto ou processo físico.

6. **COMPUTAÇÃO DE ALTO DESEMPENHO**
   Refere-se à prática de utilizar a capacidade computacional para ter um desempenho maior. São sistemas que normalmente funcionam acima de um teraflop ou $10^{14}$ operações de floating-point por segundo, afin de resolver problemas altamente complexos em ciência, engenharia ou negócios.

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**Figure 5.** US Ranking from 2016 Global Manufacturing Competitiveness Index. Council Competitiveness. Deloitte, 2015 - 1st Brazilian Congress of Industry 4.0 Fiesp - Part I

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As dez tecnologias mais promissoras segundo o Conselho de Competitividade dos Estados Unidos em parceria com a Deloitte.

7. **ROBÔTICA AVANÇADA**
   São máquinas ou sistemas capazes de aceitar comandos de alto nível orientados para missão, por exemplo, navegar para um local de trabalho e executar tarefas complexas em um ambiente com um mínimo de intervenção humana. Uso de Inteligência Artificial e Machine Learning.

8. **MANUFATURA ADITIVA (IMpressão 3D/SCANNING)**
   É um processo aditivo de construção de objetos, camada sobre camada, em oposição a metodologias de fabricação subtrativa como usinagem. A digitalização 3D é um método rápido e preciso de transferir as medidas físicas de um objeto para um computador em formato digital e de forma organizada, resultando no chamado 3D scan data.

9. **OPEN-SOURCE DESIGN / INPUT DIRETO DO CLIENTE**
   Open-source design ou open innovation refere-se à resolução de problemas através da solicitação de ideias e opiniões sobre produtos ou serviços de pessoas internas e externas à empresa, ajudando assim, a avançar o potencial de inovação com um conjunto mais amplo de constituíentes.

10. **REALIDADE AUMENTADA**
    Tecnologia que adiciona visão de computador e reconhecimento de objetos para tornar a informação interativa e manipulável pelo usuário. A realidade aumentada enriquece o mundo ao redor do usuário.


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**Figure 6.** US Ranking from 2016 Global Manufacturing Competitiveness Index. Council Competitiveness. Deloitte, 2015 - 1st Brazilian Congress of Industry 4.0 Fiesp - Part II
The operations management literature shows that, for the expected impact on performance, the technologies adopted must be aligned with the company's competitive priorities and production model. In this way, generic recommendations for adopting systems that do not take into account the segment and the market served by the company are not feasible. Another important factor is the application of technologies that have emerged outside the industrial environment and are not familiar to the technology teams of that environment. Technological artefacts, when used in different contexts, present different capacities. (VIEIRA, 2017).

Simple screen touch navigation, custom displays, shortcut buttons, and ease of information exchange are beginning to transform the shop floor into a digital environment, appealing also to the connected generation of young manufacturing professionals. (SIMON, 2016).

2.6 Industry 4.0 in Germany and the United States

In just 15 years, the popularization of computers and the Internet has left a trail of transformation. It is this revolution that is now invading the factory floor. Although it is a worldwide phenomenon, it is more present in the United States and Europe - and this has an explanation. For much of the last two decades, manufacturing in rich countries has shifted to the emerging world for lower costs. It was this movement that turned China into the world's factory. The Made in China model reigned absolute while the country had a vast pool of skilled labor at derisory prices. But in the last ten years, Chinese labor costs have risen nearly 190%. In the same period, the political pressure on companies to resume production in their country of origin increased due to the economic crisis. In the specific case of the United States, there was also a fall in energy prices due to the exploitation of gas and shale oil. (COSTA, 2014).

Marked by technologies such as artificial intelligence and great interconnectivity, made possible by ICT, the German program points, still in the choice of its original name, to a new industrial revolution. The fourth industrial revolution, represented by the concept of Industry 4.0, would succeed the first revolution, promoted by the steam engine, the second by electric machines, and the third by computer and industrial automation (Sergi, 2015). In parallel with these studies, other regions of the world have undertaken similar initiatives. Of considerable global impact, two US initiatives were the Industrial Internet Consortium, the promoter of the Industrial Internet of Things (IIoT), and the Smart Manufacturing Leadership Coalition, with the term Smart Manufacturing. (VIEIRA,
2.6.1 United States

Recently, a set of academic articles and official government documents have been produced about the US concerning the implications of the loss of industrial structure. Many of them suggest that US historical leadership in manufacturing is threatened and that a reflection of this movement can be seen in the country's trade balance. The trade balance of high-tech manufactured goods is in deficit, emerging from a historical surplus in the 1990s and reaching a deficit of US $100 billion in 2011. In 2003, the US lost the position of the world's largest exporter to Germany and, as of 2009, China surpassed both in exported value (PCAST, 2009) upud (DAUDT, 2017).

It is worth noting that the US form of action and the official documents analysed give the federal government an explicit role in boosting the country's advanced manufacturing development. In particular, the Defence, Energy and Health departments work together with IMIs to provide the effective demand needed to make it viable. (DAUDT, 2017).

In analysing the proposal for action in the United States, it should be borne in mind that, in addition to conferring stable effective demand, the government plays a particular role as coordinator and mobilized resources and other agents. Thus, a logic of problem-solving action is perceived, starting from a mission-oriented approach and stimulating specific projects that solve national or global challenges for the benefit of North American industry. (DAUDT, 2017).

Instead of considering themselves as competitors, the various consortia in the US see Industry 4.0 as a collective effort. (ANDERL, 2017).

In the US, and increasingly in China, on the other hand, Industry 4.0 is strongly associated with smart products, Internet platforms and the new business models that are based on them. In the US, Silicon Valley Internet companies, innovative start-ups and globally strong and financially connected venture capital providers understood the significant business opportunities provided by emerging platform economies. (ANDERL, 2017).

2.6.2 Germany

According to a recent survey by the Boston Consulting Group (BCG), the impact of Industry 4.0 will be significant. In Germany alone, for example, Industry 4.0 will
contribute about 1% per year to GDP for more than 10 years, create up to 390,000 jobs and add 250 billion euros to manufacturing investments (about 1 to 1.5 % of manufacturing industry revenues). The survey further concludes that, while the overall shift to Industry 4.0 may take 20 years, in the next 5 to 10 years important advances will be established and winners and losers will emerge. (SIMON, 2016).

In Germany, the term Industry 4.0 describes a strong and technology-based vision of the future. The focus is to optimize production processes in terms of quality, price and flexibility, and provide better overall financial returns. The strategic objective is to maintain Germany's traditionally strong position in manufacturing and mechanical engineering throughout the digital transformation. (ANDERL, 2017).

A top-down approach to standardization prevails in Germany, led by government, pioneering companies and academics. The companies collaborate closely with the research community and their activities are coordinated by organizations such as Platform Industry 4.0 in order to reach a consensus based on dialogue. (ANDERL, 2017).

Germany runs the risk of lagging behind its global competitors in developing the necessary infrastructure, integrating digital technologies, the race to set standards and procedures, and the creation and development of business models. However, this threat is almost unnoticed due to the current strength of the German economy. (ANDERL, 2017).

The risk to Germany is that these US consortia can quickly establish "near-standards" and steal a march on German companies in the field of standardization. (ANDERL, 2017).

2.6.3 Conclusions of Industry 4.0 in the United States and Germany

In the US, Industry 4.0 is generally included under terms like Internet of Things, Smart Manufacturing, or Industrial Internet. Consequently, it is understood to have a much broader meaning than in Germany, covering not only the technological dimension, but also the development of new business models (intelligent services) arising as a result of Industry 4.0 (e.g. in the field of big data analysis). (ANDERL, 2017).

The Advanced Manufacturing movements result from the economic interests of several regions, led by the United States and Germany, of the availability of new technologies, with the potential to enable the strengthening of industrial objectives that traditionally impact competitiveness and also of emerging objectives, with sustainability. (VIEIRA, 2017).

Attracted by lower production costs, represented here by the high availability of
cheap labor, the world's major industrial powers shifted their output to developing countries. But in the last decade this reality has begun to change, for these reasons: The United States and Germany particularly have lost the leadership of world exporters, the industry's opportunity to provide financial returns and contribute to GDP growth, the lowering of energy prices and better and intensified use of digital technologies, are leading developed countries to internalize their factories, economic interests are driving this trend of return. Governments, pioneering companies in the adoption of digital technologies and academic research communities are working to solve the challenges for the benefit of manufacturing development in the United States and Germany.

2.7 Weaknesses and Threats for Industry 4.0 in Brazil, focusing on the workforce

The use of digital technologies in Brazilian industry is less widespread. Of total industry, 58% are aware of the importance of these technologies to industry competitiveness and less than half use them. (CNI, 2016).

As the world prepares for this new Industrial Revolution, Brazil does not seem to have realized the immense challenges that surround it. In 2013, the country bought less than 1,300 industrial robots - South Korea acquired 21,000, and China, 37,000. In Brazil, the average age of machines and equipment is 17 years - compared to seven years in the United States and five in Germany. In an era of immense technological gains, Brazilian companies are stuck with outdated technologies, which directly affect Brazil's productivity. This technological gap has several explanations. The first is that Brazil still has a closed economy. With the guaranteed domestic market, the industries set up here have less incentive to invest in increased productivity. It is no coincidence that companies exposed to international competition, such as Embraer, are precisely the most advanced in terms of technology. "Brazilian industry needs to be part of global markets to be able to import best practices," says Pedro Passos, founder and partner of the cosmetics manufacturer Natura and current president of the Institute of Studies for Industrial Development. (COSTA, 2014).

At the 1st Brazilian Congress of Industry 4.0 the SWOT analysis of the Fourth Industrial Revolution, in Fig. 7 and Fig. 8, was presented in the national context, observing only the objective contents of this topic of work, Weaknesses and Threats, among the analysed points related to the deficiency of technological infrastructure, the impacts of the Brazilian crisis affecting the availability of financing resources and unemployment at worrying rates, drawing attention to a weakness that opens the way to
a threat, that is, the lack of skilled workers enhances the threat of Brazil becoming a client of technology and not developer.

Because new industries are science-based and heavily dependent on innovation, one of the critical elements of location is the presence of highly skilled professionals with expertise in specific areas (Spolidoro, 1997). In fact, digitized and intelligently managed production processes require employees to be able to understand the basics of network and data processing technologies (Erol et al., 2016) upud (ANTUNES, 2017).

The combination of economic factors, the cost of technology, the difficulty of justifying investment and the lack of qualification of workers leads Brazil to be a follower of the initiatives adopted by the countries that are ahead in the implementation of Industry 4.0 technologies.

In spite of the intense promotional work of technology and infrastructure suppliers, industrial users in Brazil, even those showing interest in the subject, few have invested in these technologies at the lower levels of automation. According to the companies studied, the trend in Brazil is not leadership in I4.0 technologies, but to be a follower. Even new European companies that are setting up in Brazil, or who are buying new machines, show little concern for factory floor connectivity. The reasons cited are the lack of resources for investment in the current economic situation of the country, the high cost of technology in Brazil due to taxation and the difficulty of justifying the return on investment. While many agree that adherence to the I4.0 platform is critical to company's competitiveness, most cannot see new business models or gains that justify the adoption of these technologies. There is a consensus that the fleet of machines in the Brazilian industry will fall behind again, with technology lag, and that the adoption of I4.0 platforms should only happen after other leading countries do so. (Nakayama, 2017).
In fact, the concern about the qualification of the workforce is justified when comparing the factors of success for I4.0 in Brazil with the most developed countries in Europe. The Department of Science and Economic Policy of the European Union in 2016,
identified the need to import labor for not having sufficient qualification and consequently were left behind, as being a weakness of national economies.

Research by McKinsey Consulting in Fig. 9 shows that the biggest obstacle is the "Capture, Management and Retention of New Talents", with 21% of the answers.

Figure 9. McKinsey, Rafael Oliveira - 1st Brazilian Congress of Industry 4.0 Fiesp

From the sociology of technology, the term affordance determines the possibility of an agent's action when in contact with a given object. A technological tool can allow its users a range of different actions, depending on their goals and knowledge. A slide rule, for example, allows performing a series of mathematical operations to a user who knows its mechanisms, but has little utility to users without prior knowledge about its operation. In the context of advanced manufacturing, the perception of the affordances of new technologies, to model their applications, will require new knowledge, now held by different teams of the company. (VIEIRA, 2017).

The availability of extensive technological knowledge has proved to be a central concern of managers seeking the implementation of Advanced Manufacturing projects; its absence is often seen as a barrier to the adoption of features such as systems with artificial intelligence. In the cases studied, some of the projects were only made possible by the formation of multidisciplinary teams capable of dealing with innovative
combinations of information systems technology and industrial or agricultural automation. This result is consistent with the theory of affordances that positions the knowledge of the user as central to the perception of opportunities of adoption of new technologies, of affordances. Companies with different strategic priorities decided to adopt systems with different characteristics, demonstrating that Advanced Manufacturing cannot be seen as a single and rigid set of approaches. (VIEIRA, 2017).

Intelligent factories will require highly skilled profiles with specific expertise, which establishes the knowledge of the workforce as a preponderant factor of understanding the technologies, to create the necessary skills to implement digitalized and intelligent production processes.

Because new industries are science-based and heavily dependent on innovation, one of the critical elements of location is the presence of highly skilled professionals with expertise in specific areas (Spolidoro, 1997). In fact, digitized and intelligently managed production processes require employees to be able to understand the basics of network and data processing technologies (Erol et al., 2016) upud (ANTUNES, 2017).

Finally, the lack of human resources capabilities. It is clear that technological transformation requires specific skills profiles of company employees. These competences can be acquired through an internal reconversion process and/or the hiring of new employees. (ANTUNES, 2017).

The presence of educational and research institutions, capable of supporting innovative development, generates conditions for the creation of a scientific potential necessary for the development of high technology companies (Dorfman, 1983) upud (ANTUNES, 2017).

There has been a fundamental impact of new industrial policies geared towards innovation in the labor market, in particular in terms of workforce renewal. (ANTUNES, 2017).

However, the challenges are many, creating difficulties for companies in adopting these technologies. Huge investments, organizational and process changes, the need to reinforce skills/knowledge, are just a few challenges that companies face. (ANTUNES, 2017).

As the qualification of the workforce is a major obstacle in the I4.0 journey, others are placed in Brazilian industries, the lack of visibility of new business models, the management and processing of data to generate information for decision making, the lack of leadership with innovation bias in the manufacturing sector, the lack of engagement by
not understanding the return on investment, the high costs of digital transformation, and the precariousness of the basic connectivity infrastructure that characterizes disruptive change.

The term Big-Data refers to large amounts of data, which are stored at any instant, resulting from the existence of millions of systems currently connected to the network (IoT), producing real-time data. This concept raises some questions that large technology companies have been struggling to resolve: Where to store data securely and that can be accessed from anywhere? How to process this data so that it can have meaning, allowing organizations to improve operations with faster and smarter decisions? (COSTA, 2017).

As anticipated by the analyst Gartner (LANEY, 2001) upud ANTUNES (2017), who reported that the 3 biggest challenges for data management would be the 3 V's - Volume, Variety and Speed:

• Volume - Amount of stored information
• Variety - Data has all kinds of formats
• Speed - Data flows very quickly and should be treated effectively

It concludes that IT infrastructures are the backbone of Industry 4.0's procedures with the digitized network, robotics and intelligent factories, allowing the efficient flow of processes. (ANTUNES, 2017).

Currently, Brazilian companies that say they are engaged in the implementation of the I4.0 platform are, in reality, testing the connectivity of IT systems with physical devices, developing industrial equipment with greater modularity and connectivity, offering services over the Internet or in the cloud. Implanting horizontal integration in the supply chain, etc., but still on the traditional I3.0 network architecture. Therefore, while they are testing I4.0 concepts on time, they lack the basic connectivity infrastructure that characterizes the disruptive change from I3.0 to I4.0. (Nakayama, 2017).

The main reason for low practical engagement is that the I4.0 platform is not yet on the productivity plateau, still lacking definitions and standardizations, and Brazilian companies have no interest in assuming the leading role in this field. Other factors mentioned also include the high cost of investing in something that is not yet defined, the lack of visibility of new business models in this platform and the difficulty of proving a return on such investments. (Nakayama, 2017).

The author concludes that information technology infrastructures and company size are positively related to the implementation of digitized processes. On the other hand, the shortage of financial resources, the lack of workers skills, the reluctance to change
and the age of the company have a negative correlation with the implementation of the procedures of Industry 4.0. (ANTUNES, 2017).

2.8 The Pathways to Industry 4.0

The demand for customization added to the pressure for low costs and the time for commercialization are driving towards Industry 4.0.

According to Schwab (SCHWAB, Klaus - 2016) in his book The Fourth Industrial Revolution, there are four major changes expected in Industry in general:

- Changes in customer expectations;
- Smarter and more productive products;
- New forms of collaboration and partnerships; and
- The transformation of the operating model and conversion into a digital model.

Brazilian industry has a significant participation in the macroeconomic indicators, as we can verify in Fig. 10 a study of the magazine “ISTOÉ” and the National Confederation of Industry (CNI), for example, industry has a 22% share of GDP and accounts for 55% in exports.

![INDÚSTRIA 4.0](image)

Figure 10. DEVELOP S.P. - 1st Brazilian Congress of Industry 4.0 Fiesp
Under two aspects of industry in the Brazilian context, the significant importance of the sector in the economy and a process of deindustrialization that Brazil faces reflected in the stagnation of productivity, as shown in Fig. 11, we can affirm that organizations, companies, academia and government should seek to create a defined development policy in a political-economic agenda. In 2015, the share of industry in GDP and the productivity ratio Brazil / USA returned to levels reached in the middle of the 20th century.

The application of the term Industry 4.0 to package several technologies that aim to automate and intercommunicate production systems is much more related to a political-economic agenda of Western countries in search of recovering their industrial importance, as opposed to directing productive activities to the East Asia predominating since the end of the 20th century. It seems that this strategy is working to direct attention and investment, which is also observed in the clothing sector. (CARVALHINHA, 2017).

Although Brazil does not have a specially created organization for the development of these programs, public authorities provide funds for investment, as well as research groups by the National Bank for Economic and Social Development (BNDES) and the Brazilian Company for Research and Industrial Innovation (EMBRAPII) upud (VIEIRA, 2017).

Due to competitive pressures, large manufacturers may experience increasing...
pressure to focus on just one role, eliminating aspects of the business that may distract the company from becoming world-class in its chosen role. The likely result is a significant restructuring of existing product manufacturers. (CHEN, 2017).

The capability for self-management, from the restructuring that Industry 4.0 will introduce to the market, has the greatest differences:

- The possibility of anticipating coming events, such as variations in demand, thus being able to operate in an uninterrupted manner in line with the expectations of customers.
- As a consequence, the improvement of customer satisfaction and the proliferation of new markets by increasing customization and the variety of smarter and more productive products.

The determining factors of a country's innovative capacity are conditioned by the educational system, by the greater / less integration of the population into the global environment, by the transparency of development and selection of innovative projects and by the degree of protection of intellectual property rights (Freeman, 1995).

Industry 4.0 involves deep exchanges between different actors who work in electronics, computer engineering, mechanics and information technology. (ANTUNES, 2017)

New forms of collaboration and partnerships are part of the changes that Industry 4.0 will bring, vertical integration and networked manufacturing systems, end-to-end engineering along the entire value chain and horizontal integration through value networks as presented in fig. 12.
The ongoing revolution will unleash positive and negative impacts. The great challenge of corporate restructuring is the destruction of a significant number of jobs, due to the change in professional profiles (Kane et al., 2015), and it is therefore necessary to change and adapt the educational offer in the field of education and the development of new professional profiles (Weber, 2015) upud (ANTUNES, 2017).

At the human resources level, workers will become increasingly specialized, will have to perform short-term tasks increasingly difficult to plan and control increasingly autonomous equipment, integrated into decentralized decision-making processes. In industry 4.0 routine activities, which include monitoring tasks, will be wholly or partly performed by machines, so that as far as workers are concerned, their functions will be increasingly concentrated in creative, innovative and communicative activities.

The increasing complexity of the industrial system cannot be managed from a centralized organizational structure. In this way, decision making will be decentralized, based on available information, with the main actors being workers or equipment using artificial intelligence.

In 2013, there were record sales of industrial robots in the world: 179,000 units. Popularization is a result of falling prices and the new skills they are gaining. According to a study by the American consultancy McKinsey, the price of robots has been dropping 10% a year in recent decades. And their productivity is increasing. (COSTA, 2014).
In Fig. 13 we verify the stagnation of Brazil in the progression to transform the operational model of the Fourth Industrial Revolution.

Figure 13. FIESP, José Ricardo Roriz Coelho - 1st Brazilian Congress of Industry 4.0 Fiesp

In order for Industry 4.0 to become effective, it requires the adoption of a technological infrastructure comprised of physical and virtual systems, supported by Big Data (a large set of stored data), Real Time Analytics, automated robots, simulations, advanced production, augmented reality, among other information technologies and computing. (SANTOS, 2017).
In Fig. 14, Zorfatec Consulting in Innovation suggests the pathway towards Industry 4.0, beginning with planning and then adopting a pilot project to gain experience and have the opportunity to make mistakes while it is small. Based on the size of the jobs verified in the pilot phase, define the resources, become an expert in data analysis, then turn the company into a digital company and finally adopt a chain perspective, an ecosystem.

Industry 4.0 will be of great benefit to companies that truly understand what it means and to establish a long-term strategy.

3. Material and Methodology

3.1 Information Base of the 1st Brazilian Congress of Industry 4.0

Regarding the bases for the extraction of information, the recent event held in December 2017 promoted by FIESP called "1st Brazilian Congress of Industry 4.0 - Impacts and Challenges of the Fourth Industrial Revolution", it was essential to know the new technologies, the impacts that they bring to business and how to prepare for this new challenge. Thanks to this, a lot of information was gathered, and others were deepened /
clarified, facilitating the understanding of the subject, with its scope, features, relevance and complexity.

The congress was an initiative of FIESP, CIESP, SENAI-SP and ABDI. The concept of Industry 4.0, still in the introductory phase of the Congress, takes into account the increase of computerization in the transformation industry, where physical objects are perfectly integrated in Internet networks.

The program of the congress consisted of lectures and workshops. Discussion panels were held around 4 priority themes, with their objectives, discussions being mediated and expert speakers each with their approach to the theme. The four themes were:

- What is the fourth industrial revolution? Characteristics and impacts.
- Industry 4.0 initiatives worldwide.
- How can Brazil build competitive advantage in the context of Industry 4.0?
- How to prepare your company for the fourth industrial revolution? Step by step and lessons learned.

For support material, ten articles and three notebooks with content for the essential and necessary deepening on the theme were made available by the organizers of the Congress. Particularly for this research two papers were fundamental for the work presented here, given the quality of the information and the extent to which the subject is treated, they are:


CHEN, Mengmeng; BROWN, John Seely; GIFFI, Craig; HAGEL III, John; KULASOORIYA, Duleesha - The future of Manufacturing – UK: Deloitte University Press, 2017.

The references and addresses of the presentations and the Congress books are listed in ANNEX 1. From the articles, the support material and the lectures it was possible to start research related to industry 4.0.

3.2 Digital Conference "Welcome to Industry 4.0", the Impact on Food and Beverage Manufacturers

The webinar (digital conference) held in April / 2018 by Tetrapack, the world leader in carton packaging, provided insights into food and beverage manufacturers
regarding Industry 4.0 and the opportunities it brings. Vice President of Services and Quality Johan Nilsson provided the best practices on how companies can leverage Industry 4.0 to increase productivity, reduce costs and respond quickly to the ever-changing business environment. As the central focus of the conference, the five success factors for Industry 4.0 for Tetrapack's food and beverage customers around the world were presented.

Throughout the conference, electronic surveys were carried out with all the participants through an interactive system of choices of responses via the web; below we can verify the results of the three questions placed:

- What do you think is the biggest obstacle for any company to embark on a journey of digital transformation?
  - 60% change in mentality
  - 35% lack of knowledge
  - 5% lack of capital investment

- What is the biggest driver for Industry 4.0 in the food and beverage industry?
  - 59% growth in business and competitive advantage
  - 35% consumer and retail demands
  - 6% regulatory pressure

- What do you think is the most important aspect of Industry 4.0?
  - 51% partnerships
  - 32% connecting equipment
  - 17% big data.

4. Results and Discussions

Given its potential to generate productivity and income growth, industry was and continues to be important for Brazil's economic growth, with a very relevant participation in GDP and exports. The expansion of manufacturing generates employment, income and demand, and accelerates the increase of productivity, which accelerates the growth of income and demand, and such gains can spread to other sectors of the economy due to the effects of chaining on production, investment, knowledge and income.

Robots with artificial intelligence, complex algorithms that make decisions for you even before you know they need to be taken. Machines that "talk" to each other and act on the products they are producing. Vehicles that drive themselves and warn of the fact that they are about to collapse before they actually do. Welcome to the world of Industry 4.0.

Industry 4.0 will enable companies to ensure that their processes respond better to
changes in consumer trends. This will allow them to identify these trends early and automatically update their capabilities to respond to them. The transformation of the manufacturing process will be perceived by increased productivity, allowing companies to operate more efficiently and produce more, reducing costs through an efficient continuous automation process, with optimized logistics to obtain a supply chain and channels distribution and faster response to customer demand for change.

It will allow companies to streamline the four levels of their operations, giving greater oversight of the entire process, ensuring greater traceability and performance monitoring, and enabling smarter decision making. These four levels are:

- **Things** - individual parts of equipment, with data collection sensors will allow companies to monitor how a particular part is operating;
- **Equipment** - monitoring and controlling the performance of a machine or a machine line;
- **Operation Management** - will connect and monitor the performance of the entire plant; and
- **Business** - will monitor the planning and performance of the entire factory, or of several factories. For example, looking at how sales performance is related to what is being produced on the shop floor, ensuring that the company is producing products in line with demand.

Industry 4.0 brings together all elements of these four levels, allowing the company to monitor and make decisions about the enormous amount of data that will be produced, to better verify how the whole operation is working, so that smarter solutions can be found for problems as they arise. Industry 4.0 will enable enterprises to extract information from the entire system and allow a higher level of analysis than has been possible before. The increased connectivity and data analysis offered by Industry 4.0 will enable traceability and transparency across the enterprise, ecosystem, leading to the lowest possible costs and the highest possible result.

5. **Conclusions**

Opportunities far outweigh the risks of not adopting technology. With a connected workforce, connected manufacturing processes, data analysis and partner search to help chart the right course ahead, Brazilian industry will be able to look confidently at the promises of the world of Industry 4.0.
With a more comprehensive and structured approach, Brazil needs a reindustrialization project emphasizing Industry 4.0 with integrated, interconnected policies and a long-term vision, focusing on the main vocations and competitive advantages of technology-intensive companies, such as the experiences in Germany and the United States, the implementation of joint and articulated government actions, academic research institutions and industries exerting a strong leadership for the incorporation of Industry 4.0. To stimulate the incorporation of the digitization and automation of these processes in companies, seeking greater flexibility, productivity and competitiveness, as well as to stimulate the expansion of private investment in PD&I to revert the participation of the industry in the economy and to intensively increase its competitiveness. Develop partnerships to stimulate collaborative synergies with national and international B2B and B2C companies. Finally, as we have seen, a great challenge will be the management of data, in volume, variety and speed, and it is concluded that investments relevant to the expansion and improvement of the broadband infrastructure will be impacting to the success in the procedures of Industry 4.0.

Industry 4.0 will do everything to make people's work easier. However, it raises fundamental questions about what kind of jobs will be created in the coming years and what skills will be needed to fill them. How can we train or retrain employees to embrace the new work culture, what does it entail, and how to change the mindset to embrace a new era of increasing automation? Therefore, human capital is key to the transformation that is intended, the lack of digital skills is certainly a more significant barrier that can prevent Brazil from implementing Industry 4.0, leading us to be a cooperator in the technological scenario. Enabling human capital formation at all levels of the company is what we need to do:

- Increase investment and the absorption of skills. Establish a system of technical education that compares with the best globally and of world class, invest in mathematics, digital education and technology, helping to solve the shortage of skills in science, technology and engineering;
- Identify future skill requirements and improve the supply and access to quality training to support these future skills by creating an agile skill development system capable of responding to rapidly changing market needs; and
- A culture of lifelong learning and a career path, creating a way to support people in requalification.
Companies seeking to adapt their processes and equipment to the "Intelligent Factory" needed to make the most of the opportunities presented by Industry 4.0 should be thought of as a five-step process as a way to help provide the guidelines that need to be followed and processes that need to be adopted to thrive in a connected world, the five steps are:

- **Partner.** Join forces with partners who have in-depth knowledge of the technology and processes required for Industry 4.0 with the innovation capability needed to execute them. Not every company is expert in all the areas it needs to embrace every opportunity offered.
- **Log in.** Ensure that your equipment is capable of connecting with each other and with the workforce required to manage them efficiently.
- **Get involved.** Form team with subject matter experts in each part of your processes to ensure they are fit and ready to respond to the possible changes Industry 4.0 will bring. Embrace new ways of working and partner with your employees to improve qualification.
- **Analyse.** Make sure your team has the ability to analyse the data generated to make quick and smart decisions.
- **Decide.** Make informed decisions based on what the team has learned about business needs and how the strategy should adapt.

While many companies agree that adherence to the Industry 4.0 platform is critical to competitiveness, most cannot see new business models or gains that justify the adoption of these technologies. The advance of Industry 4.0 in Brazil depends on the companies' knowledge of the gains of the digitalization, both with respect to the increase of productivity as well as the opportunities of new business models, flexibilization and customization of production and reduction of the time for launching products in the Marketplace. The high cost, which is one of the main obstacles, can be attenuated with implementation in stages. Increased access to information and partner identification will help reduce uncertainty and change the company culture. The priority has been to increase productivity, which is a good thing, but the most recommended one is that the digitization effort should be carried out simultaneously in all dimensions. Associated with this, the lack of a skilled worker or a structured academic plan of qualification makes Brazil become a technology client and not a developer.

A unique formula for adoption of the Industry 4.0 platform is not ready for the
expected impact on performance, the technologies adopted must be aligned with the competitive priorities and the production model of each company. In this way, generic recommendations for adopting systems that do not take into account the segment and the market served by the company are not feasible. Every company should strive to find its model.

The logic of action geared to the development of industry 4.0 should be for the federal government to assume an explicit role in the exercise of a particular role as coordinator and mobilizer of resources and other agents.

Companies that do not adopt digital technologies will find it very difficult to remain competitive and, consequently, in the market.

6. Appendices

Annex 1 - List of Presentations of the 1st Brazilian Congress of Industry 4.0

What is the fourth industrial revolution? Characteristics and impacts:

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<th>CHALLENGES OF THE INDUSTRY 4.0 AS A LEVERAGE FOR THE DEVELOPMENT OF BRAZIL</th>
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<td>• José Ricardo Roriz Coelho, Vice President of Fiesp and Director of the Competitiveness Department of Fiesp</td>
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Credit and the resumption of growth in 2018

| • Paulo Rabello de Castro, PhD President BNDES |

Industry 4.0

| • Rafael Oliveira, Associate Member of Mckinsey |

Cognitive IoT

| • Carlos Tunes, IBM Executive |

Digitalization Connect to Transform
• José Borges Frias, Director of Strategy and Business Excellence at Siemens

Industry Initiatives 4.0 Worldwide:

Agenda for Industry 4.0 – A New Agenda for Brasilian Industry
• Rafael Moreira, Special Adviser for Industry 4.0 of the Ministry of Industry, Foreign Trade and Services (MDIC)

Development Issues for MSEs in the 4th Industrial Revolution Era
• Byoung-Gyu YU, President of the Korean Institute for Industrial Economics and Trade

Industry 4.0 – Advanced Manufacturing Technologies within Digitally Integrated Production
• Rainer Stark, Director of the Division of Virtual Product Creation - Fraunhofer Institute IPK

4.0 Industry Initiatives Around the World Israel’s Tech Ecosystem
• Karin Mayer Rubinstein, President e CEO da IATI (Israel Advanced Technology Industries)

UK Strategy and Policies for the 4th Industrial Revolution
• Lynne McGregor, High Value Manufacturing Specialist at Innovate UK

Industry4.0 Initiatives Around the World
• Suresh Kannan, Member of the Industrial Internet Consortium (IIC) and President of Digiblitz
How can Brazil build competitive advantage in the context of Industry 4.0?

Strategies for Advance Manufacturing

- Carlos Américo Pacheco, CEO of FAPESP

SUPPORTING BUSINESS INNOVATION EMPHASIS IN INDUSTRY PERSPECTIVES 4.0

- Jorge Almeida Guimarães, Chief Executive Officer of EMBRAPII

INDUSTRY 4.0

- Luiz Augusto de Souza Ferreira, Chief Executive Officer of da ABDI

Leveraging Brazilian Industry Towards Industry 4.0

- Oswaldo Massambani, Superintendent of Innovation of Finep in São Paulo

How can Brazil build competitive advantage in the context of Industry 4.0?

- Milton Luis de Melo Santos, CEO of DESENVOLVE SP

How to prepare your company for the fourth industrial revolution?
1st Brazilian Congress of Industry 4.0
- Marcos Amaral, Volkswagen's Manager of Manufacturing Engineering and New Programs

Industry 4.0 in the context of the Digital Revolution
- Eduardo Almeida, President for Latin America at Unisys

Beckhoff | The brand of New Automation Technology
- Marcos Giorjiani, Beckhoff General Manager

Supporting Material, a selection of contents on the major changes and trends of Industry 4.0
The technological race to the industry 4.0: who is in pole position?
- [http://apps.fiesp.net/fiesp/newsletter/2017/decomtec/A_corrida_tecnologica_a_rumo_a_industria_40.pdf?utm_source=akna&utm_medium=email&utm_campaign=DECOMTEC+-+%28P%FAblico+Fiesp%29%3A+A+corrida+tecnol%F3gica+rumo+%E0+Ind%FAstria+4.0%3A+quem+est%E1+na+pole+position%3F+%7C+adernos+FIESP](http://apps.fiesp.net/fiesp/newsletter/2017/decomtec/A_corrida_tecnologica_a_rumo_a_industria_40.pdf?utm_source=akna&utm_medium=email&utm_campaign=DECOMTEC+-+%28P%FAblico+Fiesp%29%3A+A+corrida+tecnol%F3gica+rumo+%E0+Ind%FAstria+4.0%3A+quem+est%E1+na+pole+position%3F+%7C+adernos+FIESP)

Launch Event Program Towards Industry 4.0

1st CONGRESS OF ADVANCED MANUFACTURING.
- Dauscha, Fraunhofer Liaison Office Brazil Director

The way to INDUSTRY 4.0
- Eng. Paulo Roberto dos Santos, ZorfaTec Consulting in Innovation

**INDUSTRIA 40 Zorfatec.pdf**

Critical reflections from the experiences of the United States and Germany in advanced manufacturing
- Gabriel Daudt e Luiz Daniel Willcox, BNDES economists

**Advanced Technologies Initiative Manufacturing & Innovation**
- Deloitte

**Analysis of Industry Practices 4.0 in Selected Countries**
- Eduardo Zancul, ABDI – FIESP

**COMPETITIVENESS RANKING 2017**
- IMD WORLD COMPETITIVENESS CENTER

**Notebooks - Clarifying the concept of Industry 4.0**

The fourth industrial revolution has arrived!
- [http://hotsite.fiesp.com.br/industria40/cadernos/Caderno1_A_quarta_revolucao_industrial_ja_chegou.pdf](http://hotsite.fiesp.com.br/industria40/cadernos/Caderno1_A_quarta_revolucao_industrial_ja_chegou.pdf)

Technologies and examples of the fourth industrial revolution

The technological race to industry 4.0: who is in pole position?

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