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Supply Chain in the Environment of Industry 5.0, Practical Case Study

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ABSTRACT

Nowadays given the new industrial revolution, it is necessary to know what challenges and advantages we can find in the supply chain. Therefore, that in turn will cause an impact before the imminent entry of industry 5.0 in a competitive environment. In addition, as well as identify the possible barriers and benefits that we can have in industry and in turn in the social sphere. In this sense, some questions will be proposed such as Is I 4.0 focused solely on technology? Does I 4.0 help meet the implementation of I 5.0? Are they interdependent or dependent on each other? What technologies and processes will we have to adapt to meet the purposes of I 5.0? Subsequently, an analysis of the logistics process of an industry in Cd. Juárez will be carried out to generate a proposal on improvement to the logistics process using the strategies of industry 4.0 and contemplating the objectives of what would be an industry 5.0, verifying these theories with a program of simulation to later see the possible scope.

1. INTRODUCTION

Throughout history, it has been seen that the various industrial revolutions have greatly helped to improve the fluidity of the supply chain, however, it is important to highlight that this has occurred at different stages and for different communities, having a common goal to achieve a competitive and sustainable advantage [1].

Therefore, with the entry of the new era and technology, it is necessary to adapt the processes to the new needs, for this reason, it is intended to review what is expected of I 5.0, what applications can start working and under what programming is intended to use the production systems and the supply chain to meet these requirements.

1.1 Background

To understand a little more about the point of focus, it will be necessary to investigate what stage of the industry our society is in, for this it is necessary to review the chronology of each of these stages to know what changes have arisen according to the needs of human beings, which are expressed as follows:

1. First industrial revolution (1760-1870): Based on the changes that existed in this period of time, the supply chain was benefited by the implementation of hydraulic power and coal, with which new techniques could be implemented in the construction of roads and streets, giving way to the beginning of the railways [1]. This stage came to revolutionize the way in which the merchandise was transported to make delivery times more efficient as well as to facilitate merchandise and services to an area where it did not exist or its acquisition was very complex.
2. The second industrial revolution (1870-1914/18): In this stage there are changes in the energy sector regarding oil and electricity, as well as the intervention of the internal combustion engine, telegraphic and telephone transmissions, application of financial capitalism [2]. This brought economic and industrial expansion, due to the increase in production using new machines.
3. The third industrial revolution (late 19th century): In this revolution, development is more focused on networks and telecommunications, as well as mass transportation systems in all areas [3]. At this stage, an approach to the development of information systems and computers is seen, therefore the processes and production in the industries was much faster, helping to improve transportation services under the motto of being used with renewable and sustainable energy.
4. The fourth industrial revolution (Early 20th century): This is characterized by creating smart factories, whose characteristics are greater adaptability to production needs and improved resource efficiency [4]. Focused on what is robotics, cyber-physical systems, the internet of things and the connection of devices. Thus, causing a considerable impact on society and the entire supply chain.

Now, once you know what these stages are, you should ask - What is the current state of industry 4.0 in the supply chain? And how has it been implemented today? Consequently, from the implementation companies have seen the need to adapt their production processes and thus make adjustments to costs to have a better time to market, as well as improve collaboration with their customers and suppliers through customization of interconnecting products, services and processes to benefit the supply chain [5].

Therefore, in the supply chain it is necessary not to neglect a single dimension that forms part of it, since doing so could see the entire implementation and improvement of it stunted [5].

The lessons that derive from this and that must be considered for its proper functioning are:

1. Industry 4.0 requires fundamentally new skills from employees.

2. It requires change related to various research and knowledge instruments.
3. Necessary organizational changes in a flatter structure and decentralized decision-making, strong links with spin-offs and the reduction of multidisciplinary teams.
4. Changes in corporate culture and culture in companies, characterized by their flexibility, openness, and willingness to learn an entrepreneurial mindset.
5. Openness and trust required to share data with partner companies in the supply chain.
6. There must be integration in the industry regarding machines and production systems.

Based on this, it can be deduced that for a correct scope of the implementation of the supply chain in industry 4.0, it is necessary to treat each phase as a case for the correct functioning of the various activities that make up the chain, and with this achieve a proposed maturity model for the industry, creating an improvement in productivity and flexibility for the organization.

However, this would result in an impact on industrial manufacturing and management areas, as well as logistics and business process management, where Companies must adopt emerging technologies in their business processes and manage the growing flow of data in their value chain to effectively manage next generation digital supply chain needs [6].

Being this way, it turns out that the benefits that the supply chain attracts in industry 4.0, would be those based on the implementation of automated systems that allow us customization, agility and speed in manufacturing and service operations, by providing data of various devices, sensors and tools [7].

In addition, it is necessary that there are Capabilities that include highly organized interconnections, monitoring and control in real time of materials so that they in turn help the overall performance of the value chain and risk reduction [2].

Table 1. Business dimension of I 4.0 in the supply chain

Dimensions	Driving Forces	Barriers
Organizational	Increase efficiency	Financial restrictions
	Costs reduction	Lack of administrative support
	Agility	Resistance to change
	Quality improvement	Lack of vision and digital strategy
	Balanced loads and inventory reduction	Lack of experience and complex network systems
Ethics and legality	Reduction of monotonous jobs	Legal issues and coordination and collaboration issues
	Reduction of environmental pollution	Information privacy and security issues.
Strategy	New business models	Profiling issues and complexity, lack of policy and government support
	New value offers to improve competitiveness	Lack of infrastructure development, lack of economic benefits
Technologies	Transparency	Lack of digital culture, digital infrastructure, poor quality, and data management

Now, for the moment, only the benefits have been covered, now the counterpart of this will be reviewed, which would be the barriers that may arise, where they affect the business environment and include problems such as lack of data, risk of information security, lack of qualified labor, among other things.

Having defined the advantages and disadvantages, we proceed to explain a comparative Table 1 between the processes that drive the supply chain as well as its barriers.

With all these digital, demographic, social, cultural, and governmental changes, I 4.0 is transforming the business model in many industries where the supply chain is presenting a great metamorphism in all its areas in order to reach the new era and create the necessary changes for the correct support of the processes and the ease of activities for human life.

1.2 Problem statement

Before the new needs of society and the arrival of the new era, the supply chain will also be affected and must adjust to the change that is demanded. Therefore, it is necessary to know what the new needs of society will be and what role it will play to satisfy it in conjunction with the new era of technology, this in order to know what organizational changes will be seen and what area of opportunity we can find in it as a society, through the analysis of various texts related to the future entry of I 5.0 and the impact that I 4.0 has had.

Additionally, it is intended to analyze the impact of resilience that can be added to the supply chain as performance indicators when making a decision on programming and thus be able to measure the quality index of the stages. This is intended to be measured through a simulation process which will take into account all the possible states of execution of the schedules, taking into consideration the availability capacity and possible affectations.

1.3 Hypothesis

Considering the approach to the specific problem, it is emphasized that the main activity to be carried out is to propose various solutions to a production line to see its behavior in the face of the need to adapt to the new needs that the demand for the specialized product suggests, based on, production times and idle downtimes of the production line, to determine what problems could arise and later offer alternatives for their solution.

1.4 Objectives

General objective: Analyze the supply chain in the face of the future entry of I 5.0, taking literature as a reference.

Specific objective: Identify the benefits and barriers faced by I 4.0 and consequently to the entry of I 5.0.

1.5 Scope and delimitations

Carry out a case study to analyze the logistics that impact production using a simulation system called Flexsym. It is intended to use real data from the company where the data collection will take place. Only the data that the company allows access to will be taken.

The case study will only analyze the logistics from the purchase phase to the stage where production begins the assembly of the product.

While we understand that the supply chain is the basis for achieving a significant competitive advantage, it has been in need to undergo changes or adjustments due to the passage of

the various industrial revolutions that have taken place throughout the history of mankind with a positive purpose.

2. THEORETICAL FRAMEWORK

2.1 Industry 4.0

Now talking about the next industrial revolution, the implementation of the supply chain in industry 4.0, it is necessary to treat each phase as a whole case for the proper functioning of the various activities that make up the chain, and thereby achieve a maturity model proposal for the industry by creating an improvement in productivity and flexibility for the organization.

Now, this would result in an impact on industrial manufacturing and management areas, as well as, logistics and business process management, where companies must adopt emerging technologies in their business processes and manage the growing flow of data in their value chain to effectively manage next generational digital supply chain needs [6].

With all these digital, demographic, social, cultural and governmental changes, I 4.0 is transforming the business model in many industries where the supply chain is presenting a great metamorphism in all its areas in order to reach the new era and create the necessary changes for the correct support of the processes and the ease of activities for human life.

2.2 Industry 5.0

Although this stage of the industrial revolution is still in an embryonic phase, it is important to know what stages are intended to be covered, what changes could arise, but above all, what new labor challenges we will face.

While Industry 4.0 is more concerned with the application of disruptive technologies, Industry 5.0 focuses on enabling a 5.0 society, that is, a human-centered, sustainable society, by using the same I 4.0 technologies, but taking into account the formalization of a 5.0 society that goes beyond the limits of the technological and organizational transformation of the industrial system, so it implies considering social and human aspects to achieve a technological environment [6].

It is noted that I 5.0 in conjunction with the 5.0 society uses advanced technologies and products to connect people and things, share knowledge and information to then create new social and commercial value chains within different communities.

Various authors claim that a 5.0 society environment frees humans from exhausting routine jobs exploring the advantages offered by industry 4.0 by implementing the combination of robots with human brains, which in a matter of seconds could develop much greater potential than already exists in order to improve productivity, reduce waste and improve sustainable goals.

In addition, other authors state that I 5.0 will enable customized products on a large scale, adding high value to customers [8]. It contemplates that the supply chain will involve four main trends which are:

1. The collaborative, work between humans and robots (cobots).
2. Mass customization.
3. Personalization for customers in a super intelligent society.
4. Align technology advancement with human empowerment.

Taking into consideration that the I 5.0 continues to be a visionary concept that aims to include the human, social and sustainability in the technological field and highly focused on industry 4.0 still, where the supply chain aims to focus more on customization services by adding revolutionary technologies and superintelligence together with a sustainable society, this without neglecting the fact that transition challenges need to be faced [8].

2.3 Experimental case

The logistics phases that will be studied for the development and analysis of the simulation process are detailed as follows (Figure 1):

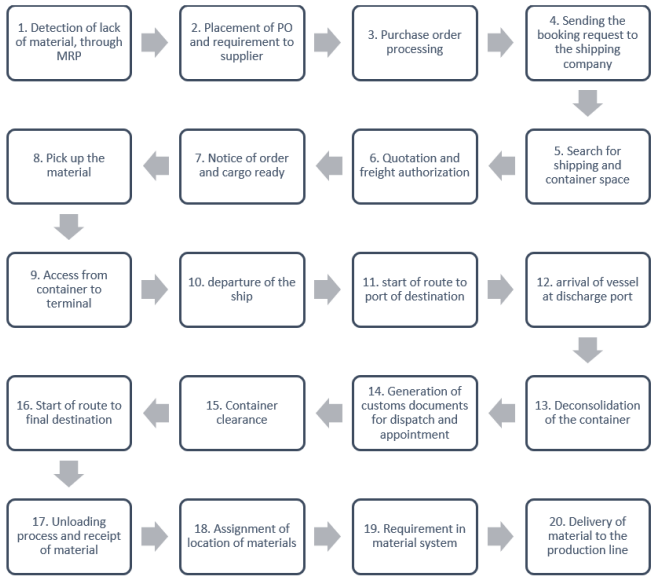

Figure 1. Flowchart of the logistics process

Of which said phases are explained as follows:

1. Detection of lack of material or order request programming: This stage is determined as the first in which a pre-alert is generated about the reorder point or through the already predetermined programming according to the week and the consumption indicated so it is necessary to place the requirement.
2. Placement of PO and requirement to the supplier: Once the amount required is detected, it is necessary to generate a purchase order in the system, which must be sent to the supplier, to finalize the purchase and said requirement.
3. Purchase order processing: Once the supplier knows the requirement made by the client, they begin to make the necessary arrangements to be able to fulfill the purchase order.
4. Send reservation request to the shipping company: Once the supplier begins to work with the purchase order, he must analyze the processing time in advance, to generate a reservation request three weeks in advance to the corresponding shipping company in order not to generate a collection time after the completion of the requested purchase order. Therefore, the reservation request is sent as soon as you have the estimated completion date of the PO order, this can be in parallel to the start of your production system.

5. Search for space in shipping company and container: In this section, as soon as the supplier sends the reservation request, the shipping company begins to search for a container to transport the merchandise, and space on the ship to reach its final destination.

6. Quote and freight authorization: Once the transport company has a preliminary search, they send the quote to the client for authorization and proceed with the necessary arrangements.

7. Notice of order and load ready: Once the supplier completes the order, a confirmation notice is sent to the transport to confirm the day that pickup will be generated.

8. Collection of the material: Given the notification, the container is placed in the plant to load the transported goods.

9. Access of the container to the terminal: Once the collection has been made, an appointment is made to place and leave the material at the port of departure for dispatch.

10. Departure of the ship: After the export clearance, the vessel begins its transit to reach the port of destination.

11. Start of route to destination port: The vessel begins its non-stop route from the port of Shanghai, in China, to the port of Ensenada in Mexico.

12. Vessel arrival at port and unloading: Once the ship anchors, a few days later it will get in line to get the transported containers to be lowered to the ground.

13. Deconsolidation of containers: Once on the floor, the containers are placed on the corresponding platforms to be inspected before modulating at customs.

14. Generation of customs documents for appointment clearance: The capture of the declared merchandise is generated to modulate in customs.

15. Dispatch of container: Documents are presented before an automated random mechanism system.

16. Start of route to final destination: Starts its consecutive route from Ensenada to Cd. Juárez, Chih.

17. Unloading and reception of material: Once it reaches the final destination, the material is unloaded in the warehouse to enter the part number into the system.

18. Assignment of locations to material: Once received and inspected in the system, a location is assigned according to the system, composition of the material and order of priority. For this part number, we proceed to enter the terminals close to production.

19. Material requirement in the system: As soon as it is requested in production, it is ordered to be purchased internally via the production system to the warehouse.

20. Delivery of material to the production line: Once the purchasing process is completed, the material is supplied to the production line as soon as it is needed.

To generate the corresponding algorithm, the following points will be required:

- Amount of the requirement or demand used: 295, 238 (2021)
- Supplier delivery time: 168 days
- Times of each phase:

1. 1 day (1hour)	2. 1 day (1hour)	3. 168 days	4. 1 day (15min)
5. 30 days	6. 1 day	7. 1 day (15 minutes)	8. 1 day (3 hours)
9. 7 days	10. 3 days	11. 3 days	12. 3 days
13. 7 days	14. 3 days	15. 1 day (2 hours)	16. 2 days
17. 1 day (4 hours)	18. 1 day (2 hours)	19. 1 day (2 hours)	20. 1 day (2 hours)

- Cycle time
- Production volume: 2,200 pieces per day
- Transportation method: Maritime
- Transportation costs: Average per container $10,927.64 USD.

3. METHODS AND MATERIALS

This work is carried out using the following methodology and materials:

1. Descriptive method.
2. Interpretive structural model.
3. Literature analysis Prisma (Figure 2, references the transcendence).
4. Simulation of the logistics process using flexsim.

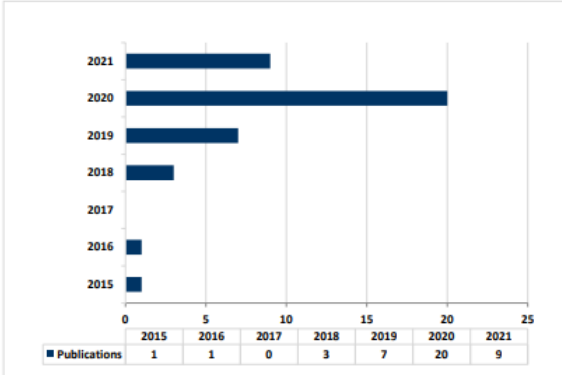

Figure 2. Number of publications from 2015 to the present, regarding I 5.0 and the supply chain

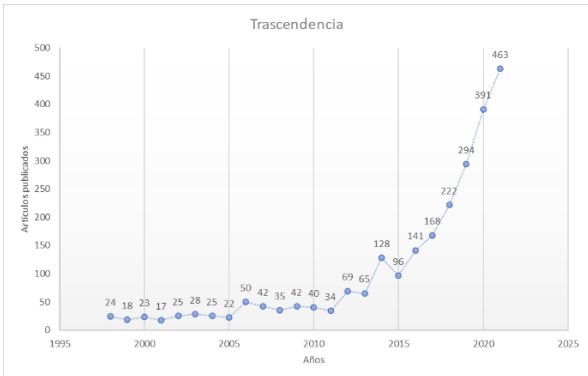

Figure 3. Importance of the supply chain in Industry 5.0

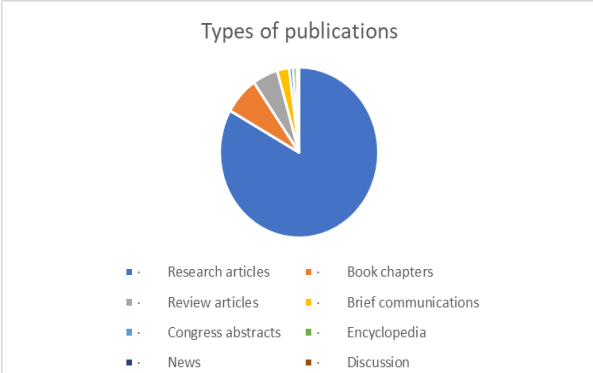

Figure 4. Importance of the supply chain in Industry 5.0

where, said table shows the increased impact in the last two years, which shows that the trend is increasing, with respect to the topics covered shown in Figure 3 and Figure 4.

This trend increasingly grows since 2020 and 2022, even since 2014 you can see an increase in contributions to this topic with respect to the previous one, however, during 2021, the change was greater in relation to all previous years.

Significance of the types of publications with the highest level of contribution (1999-2022).

- Research articles: 82.78%
- Book chapters: 7.15%
- Review articles: 5.17%
- Brief communications: 2.42%
- Congress abstracts: 0.80%
- Encyclopedia: 0.78%
- News: 0.26%
- Discussion: 0.17%

4. PRELIMINARY CONCLUSIONS

From the literature analysis it is found that the different existing algorithms applied to problems of missing operations, it should be noted that they produce accelerations that can allow solving large instances of reasonable time [9] considering that it must have a limit adjusted to a specific operation so that it can give a better result. Therefore, in response to this issue, the aim is to improve the logistics process, to generate a reduction in time, taking as a starting point the critical path of the different stages, resulting in meeting the new market demands, such as specialized products.

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