Trabajo Fin de Grado

Logistics in the Automotive Sector, Industry 4.0 and sustainability approach

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RESUMEN

La industria del automóvil es un sector clave para la mayoría de los países del mundo debido a que en las últimas décadas el automóvil se ha convertido en uno de los bienes de consumo más importantes así como en una fuerza de arrastre de productos en otras industrias. Además, cuando se trata de adoptar las últimas tecnologías, la industria del automóvil siempre se ha mantenido a la vanguardia.

El objetivo de este trabajo es describir la evolución de este sector desde el comienzo de la producción de automóviles hasta su situación actual, explicar cómo los avances en esta industria han afectado a otras y analizar cómo la Industria 4.0 está siendo implementada para hacer frente a los cambios tecnológicos que están siendo experimentados en el sector.

ABSTRACT

The automotive industry is a key sector for most countries in the world since in recent decades the automobile has become one of the most important consumer goods as well as a driving force for products in other industries. Moreover, when it comes to adopting the latest technologies, the automotive industry has always been at the forefront.

This paper aims to describe the evolution of this sector from the beginning of automobile production to its current situation, explain how the advances in this industry have affected others, and analyze how Industry 4.0 is being implemented to cope with the technological changes that are being experienced in the sector.

AGENDA

1. INTRODUCTION

The automobile industry is a capital intensive and knowledge-intensive industry that plays an important role in the socio-economic development of a wide range of countries (Saberi, B, 2018). The industry invests more than 74 billion euros in research and development, for this reason, the Automotive industry is considered a major innovator. Currently, the industry is booming, involving an increasing number of countries in the production of cars, the trends for the higher vehicles production has changed drastically, supposing the rise of the Asian continent as the most important to world production, leaving America and Europe in the background. (Saberi, B, 2018). The underlying technology in this sector has also experienced radical technological innovations, with the increasing popularity of diesel, hybrid, and fully electric vehicles helping to diversify the market. Changes in the regulatory environment and international production processes have also molded the industry, making more efficient cars accessible to the mass public.

The automotive sector worldwide has been characterized by a constant process of restructuring, which had made it one of the most dynamic industries of the modern era, generating important effects on the different economies in terms of productivity, technological development, and competitiveness. To occupy the first places in terms of productivity and sales in the world markets the companies of the sector have been always searching for innovations that allow them to strengthen and make more competitive their production processes.

Nowadays, the introduction of Industry 4.0 has started the fourth industrial revolution in the automotive sector. It will be a major trend relying on the digitalization along the product life cycle in the automotive industry and will have a high potential in terms of competitiveness and generating new opportunities. Especially the digitalization of the supply chain will allow the reduction of costs because of an improvement in data quality and the reduction of fragmented information. To achieve a transition to a digital world is a complex process that will need some technologies like the Internet of Things (IoT), Big Data, 3d printing, or nanotechnology (Dos Santos, L. P., Coti-Zelati, P. E., & de Araújo, D. L. A. (2020).

The objective of this work is to highlight the important contribution of the automotive industry to operations management. To achieve this objective, we are going to complete four sub-objectives. The first one consists of the evolution of the sector from the beginning of the vehicle's production until the current situation. This part will explain Henry Ford's production method, the Just in Time method, and the evolution of the production during the last fifteen years. The second sub-objective will be explaining how all the advantages of the automotive industry have been introduced in other industries. To achieve this objective the work will include in a schematic way how the most important revolutions of the automotive sector have been adopted in other industries. The third sub-objective is going to make an analysis of the current situation explaining how the industry is moving towards Industry 4.0 to be adapted to the emergent technologies. Finally, the fourth sub-objective will include the future tendencies of the sector in terms of sustainability.

2. EVOLUTION OF THE AUTOMOTIVE SECTOR

2.1 THE BEGINNING

The history of the automobile industry has a lot of importance if it is compared with the rest of the industries. The first automobile originated in Germany, but thanks to mass production, the United States dominated the world industry. The situation in the industry changed completely during the second half of the century because of the rise of the western European countries and Japan, which became the biggest producers and exporters.

The fabrication of vehicles started with the steam-powered road vehicles, but this tendency changed rapidly in the 1860s and 70s towards the gasoline engine mainly in France and Germany, although at the beginning of the 20th century those countries were joined by Italy, America, and England.

Before the First World War, most early automobile companies were small shops. Those that survived had certain characteristics in common, they fell into three defined categories: they were markers for bicycle producers, such as Opel, builders of horse-drawn vehicles, or most frequently, machinery manufacturers (Rae, J. Bell and Binder, .

Alan K. 2020, November 12). The first manufacturers had to deal with a wide range of problems with finance, technical problems, or decisions about what to produce. The gasoline engine supposed the experimentation with steam and electricity. This second type of energy enjoyed more acceptance for some time because it was easier to operate, but the battery capacity was an important limitation. Nevertheless, electric cars remained in limited production thanks to the popularity among women. The steam power was considered a more serious competitor given that it was easy to operate thanks to its simple transmission, but the high amounts of money which were needed to create quality engines supposed that most manufacturers changed to the gasoline engine in 1910.

The introduction of mass production was considered one of the biggest technological advances in the automotive industry, a process that consisted of standardization, synchronization, and continuity. This technique started in the United States and was characterized by two movements: Taylorism and Fordism.

According to Gonzalez (2003) "*Taylorism or Scientific Labour Administration is based on two fundamental strategic principles focusing on reconfiguring the task of the individual worker, his time of implementation and the instruments and conditions of implementation*". The first principle states that between the range of methods that are used to carry out a job, there is always a faster method and a better instrument. Those methods and instruments will be developed thanks to a scientific analysis involving all the available procedures and instruments and a study of the times and movements which are needed for each operation. The second principle says that those studies can be only carried out by the management of the company using specialized departments. Those working methods appear due to the reunion of worker's traditional knowledge, classifying it, and creating rules that will create a scientific method to substitute the worker's empirical knowledge by other rigid knowledge with rigid rules for the movement of each man.

The basic tools of the Scientific Management of work are the so-called Time Studies and movements. Through these, research on how each of the movements and gestures of the workers is analyzed. Subsequently, the decomposition of this process into a set of simple manipulations that are selected, measured, and reduced to a standard, eliminating the unnecessary and excessive movements are re-integrated according to Taylor as "The only best way".

It had not only studied the operations and time to set standards, but it also wanted to redesign the production process to eliminate unnecessary movements and to reduce the time of each operation to a minimum to achieve the intensification of the operator's performance. To achieve these effects, the working methods designed by the management offices should conform to the following rules:

- The operator must receive only the essential information at the essential moment
- The interpretations and the decisions of the operator must be automatic, which means that the elections to be executed by them should be as few as possible and allow them to execute the task in the shortest time possible.
- Each specific task must require the minimum of energy and the lowest voltage expressed in calories per minute and beats per minute.

The application of those rules implies that the successive stages of the process are subject to an ever-increasing subdivision of its parts components, systematically dismembering them into their simpler elements. This subdivision of the work has the following advantages:

- A high degree of specialization allows the workers to learn their tasks in a short time and perform with excellence.
- A short working cycle allows a fast execution and almost automatic with little or no mental effort.
- Less supervision is required since the operator quickly learns his task.

2.2 HENRY FORD

Henry Ford became a follower of Taylor's work and a bridge between the liberal businessman and the arising from the crisis of free trade. Ford used Taylor's labor process heritage in the automotive industry to solve the problems of production to eliminate unnecessary work and achieve the objective of producing in series at a lower cost. The paradigmatic Ford T (1908) was so successful that it prompted the need to increase production. This led to the implementation of a new model production based on the serial assembly line, where operators assembled parts that were transported on continuous motion belts (Piñero, F. 2004).

The characteristic working process of Fordism is the semi-automatic production chain. By mechanizing work, Fordism managed to raise the intensity, while increasing the separation between manual and intellectual work. As far as the production process is concerned, Fordism surpasses Taylorism following two complementary principles. The first one is the integration of the different segments of the work process using a system of guides and means of maintenance that allow the movements of raw materials in the process of transformation and their driving in front of machine tools. The second principle, complementary to the previous one is the allocation of jobs according to the configuration of the machines. This principle causes the worker to lose control of the work rhythm, by subjecting operators to the uniformity of machine movement.

These principles also make it possible to increasingly simplify the work through the fragmentation of movement cycles, creating situations in which the workers only perform extremely simple and routinary movements. The job simplification allowed an improvement of the chain performance, which is modified quantitatively and qualitatively at the same time that new jobs are created.

With the use of the assembly lines, Henry Ford rebuilt the labor process in the automotive industry, where the assembling technical limits represented a serious obstacle for the production continuity. The use of the assembly line in the automotive industry was the result of a long process; all the Fordian transformations that were done in the production organization were the result of long years of experimentation. The dismantling of the work at the Ford plants was carried out between the years 1903 to 1914. That period became in a timeline formed by a succession of measures, which were aimed at control and discipline imposed by the chain assembly line that would later extend its domain to society.

In 1903 Ford’s facilities still used the service of versatile mechanics, who moved along the assembling line route as global mechanics and followed the car elaboration, from the chassis assembly to the product termination. In 1908, the assembly workers no longer had to leave their jobs to make trips to the warehouse and provide themselves with tools, the assistants placed at their side performed that work.

Between 1908 and 1909, Henry Ford and his partner James Couzens decided to hire the services of Walter W. Flanders to modernize the manufacturing process of the assembly machines. He was the one who provided them with the equipment and essential machinery to start the mass production, which in 1909 reached the number of ten thousand produced cars. Nevertheless, the disorder with the connected departments to the final line was not solved. The firm step towards the production's rationalization consisted of the Taylorism measure of dividing, until the smaller units, every mechanical operation required for the automobile production. The next step consisted of accommodating machines and workers in continuous and parallel lines with the intention that workflows from machine to machine with as little interruption as possible and in a logical succession. The main principle that guided the transformation in the facilities was the search for a higher continuity in the production process, nevertheless, the workers and the pieces to assembly still had to be in movement. In 1910, to avoid the workers' movements sloping surfaces were installed to allow that pieces were moved by themselves. This improved productivity of departments that were in charge of the production of parts that were connected with the final line.

The new methods were applied to all the final line departments and in 1913 the stationary assembly was modified. The rudimentary system consisted of placing sixty chassis in line and next to it, in a parallel line, the body works were placed in wood structures waiting to be installed. Meanwhile, the workers carried out their activities over the sixty chassis. There were teams dedicated to the assembly of axles, engines, tires etcetera. Every teamwork was followed by assistants who provided them the necessary tools and pieces. As can be observed, the new technique was still really archaic. Consequently, the principle of "Bring the work to the man" was implemented, giving mobility to the engine and axes lines. The results were really good but after some weeks, the decompensation between the department's speed and the slowness of the assembly line appeared. This year the final assembly in the movement was achieved. Simultaneously the automobiles were approached by the workers who were in charge of placing the pieces in the chassis. In February of 1914 was the first time that an automatic assembly line was used, and later the first aircraft carrier was used to supply the workers.

Some of the contributions that Fordism left were:

Fordism Contributions	Automotive industries and other industries
Increase in the division of labor	✓
Chain production system	✓
Production cost reduction	✓
Exercised control over Workers' productive time	✓

2.3 JUST IN TIME METHOD AND TOYOTA

Just in Time (JIT) is a technique developed by Taichi Ohno at Toyota. The main purpose of this system was to change the production directives from estimates of demand to fundamental demand (Ballard, G., & Howell, G. 1995). The JIT concept is not only useful to control materials, stocks, and work in progress. JIT was developed by Toyota to take advantage of the use of workers and eliminate wastefulness, which is affected by overproduction, transports, stocks, or defective products. The Toyota system considers the stock of all of them as the largest sources of problems and difficulties; they are the most damaging waste given that they conceal the problems and cause other wastes (Pascual, R. C., & i Guardiet, J. B. F. 1989).

The main idea of the system is to produce the necessary articles in quantity, quality, and time, all of these objectives can be achieved thanks to the two pillars of the Toyota system, which are JIT and the JIDOKA system.

In assembly line production systems which are managed by lean production concepts, the directives for production are provided utilizing kanban from downstream processes. This system ensures that whatever is produced is needed for the production of an order. Kanban works as a near term adjusting mechanism within a system of production scheduling that strives for the firm and stable aggregate output quantities, and provides all suppliers in the extended process progressively more specific production targets as the plan period approaches, resulting in a firm 2-6 week production schedule. This system provides sufficient flexibility to adjust to actual demand while assuring that all resources are applied to the production throughput.

The use of JIT techniques helps to reduce both stocks superfluous in the warehouses such as intermediate or buffer stores, reducing storage costs, and increasing the ratio of capital turnover. The JIT method seeks to produce what is needed, in the necessary quantity, at the right time, and with the perfect quality. The final objective will never be achieved, but it must be pursued persistently and continuously to get closer and closer to the ideal. This main objective leads to a certain number of sub-objectives, like for example, as a preliminary matter, to know which is the minimum level of stock and work in progress imaginable and the reasons that make working with higher levels.

2.3.1 JIT Characteristics

<u>JIT Application Difficulties</u>

Although the JIT method is really useful to control materials, stocks and reduces wastefulness, its application is not simple. In the following table, some of the JIT application issues and the proposed solutions are presented.

Problems	**Proposed solution**
The increase in the adjustment frequencies need a lot of time and the working force	To simplify and reduce the preparation time thanks to the individual adjustments techniques and better workforce's training
To produce diverse products in the same facility, a high level of flexibility is required.	Multipurpose machines will be used
The use of the equipment is reduced	It must be avoided, but it can be used in certain cases and within some limits.
The facilities must be very reliable and of a high standard	The reliability and durability of the machines must be guaranteed thanks to an excellent maintenance system.
Operators must have a high level of standard	This competence is achieved thanks to the training and hard motivation

There are problems concerning the workshop level of production	Kanban system
Production is sensible to the demand fluctuations and to the changes which interfere in the production elements interfere in the production elements	Problem solved thanks to the visual control and polyvalent production lines

Source: (Pascual, R.C., and i Guardiet, J.B.F. 1989)

Concerning production systems management there are two critical problems. Firstly, the general demand is very fluctuating. Secondly, there exists a necessity of controlling time lags and the consequent setting priorities at work. The JIT method seeks to address both critical problems through careful monitoring and to authorize and control activity, and control of work rhythms, accompanied by a constant intervention by workers and managers.

Although JIT and Kanban are a fundamental part of the Japanese industrial management systems, they depend on some conditions which directly affect the operations management; these conditions are the product designs, the task normalization, and methods of improvement and product regularization.

2.3.2 Product designs

In process design and distribution in plants, the Toyota system takes into account not only stock problems and information flow but also seeks to smooth the production flow. For this reason, the machines have been approached and each operator must be able to handle three types of machines at the same time. This concept is known as multi-process holding, it is an evolution from the classical operator to the multifunctional operator. This new disposition leads to the elimination of stock between processes, increasing productivity and motivation of workers. It allows changes in the allocation of machines to workers according to the production rate required and allows the creation of working groups or establish cooperation between operators in the course of work. To achieve this cooperation there is a light board located to make it easy to see; when an operator needs help to eliminate the delay in a task turning on a yellow light on the platform, if the operator needs the line to stop to correct some problems with the machine, the red light will be turned out. (Pascual, R.C., and i Guardiet, J.B.F. 1989)

2.3.3 Task normalization and method improvement

All tasks are standardized and there is a written description of which can be viewed and contains the following elements: the cycle time, the route of operations, and the standard amount of work in progress. Normally the components of the operations, the routes, and cycle times are set by the foreman at Toyota.

According to Ramón Companys Pascual and Joan Fornollosa Guardiet, who wrote in 1989 "*Nuevas técnicas de gestión de stocks: MRP y JIT'' One* of the most spectacular method improvements in the Japanese industry refers to the rapid tool change, especially the matrix of the syringing presses. In 1970, Toyota asked S.Shindo, the creator of the SMED system, for a collaboration to reduce the change in the matrix time frame of a 100-ton press. In those times the change was in 4 hours, after six months of work, a reduction to 1 hour and a half was achieved, but Taichi Ohno wanted to reduce the time to less than three minutes. S.Shindo established a list with the eight points to work to reduce the time and achieved to make the change in less than 3 minutes.

The four fundamental characteristics for the SMED method (which means, tool change expressed in one digit, inferior to 10 minutes) are the distinction between interior time (Machines is not working) and exterior time (Machine is working), to transform if it is possible the interior and exterior time, to improve the means of fastening and to eliminate the manual adjustment.

The SMED adoption had three effects. The first one allowed the reduction of unproductive changeover times leading to an increase in the rate of machine use. The second one was related to the production of very small batches which allowed the reduction of finished and ongoing product stocks in a spectacular way. The third effect increased the flexibility to allow almost the immediate adaptation of the production to fluctuation in demand and variations in deadlines, which again allowed the reduction of finished and ongoing products.

2.3.4 Product regularization

This is one of the most important conditions in the Toyota system to reach the JIT due to the implementation of the Kanban system, which is an information system that harmoniously controls the production of the necessary products in the quantity and time required in each of the processes that take place both within the factory and between different companies. The product regularization will make the higher difference between the Japanese way of production and the rest of the production methods. The operation management will be structured in three parts.

The first one is the planning, at this level, there is no difference between the kanban system and any other. At this stage, the aim is to define the master production. However, it should be noticed that the kanban system will only be applied correctly in the stable mass production; the master plan will be expressed in monthly (or daily) rates for each finished product.

The second part of the product regularization is programming, in this part, there are also few innovations. From the master plan and the list of materials, the provisional monthly takings are determined for components, subassemblies, and materials. However, the kanban is limited to economic regrouping and adapts, within certain limits, to the capacity to load and not vice versa. Finally, the component flows are as regular as possible throughout the month, making the daily production rates of the finished products almost constant within the month.

A Toyota's example can be analyzed from the book "*Nuevas técnicas de gestión de stocks: MRP y JIT''*. It is supposed that 10.000 must be produced in 20 labor days in 8 hours; the vehicles are distributed in 5000 sedans, 2500 coupes, and 2500 vans, which mean 250 sedans, 125 coupes, and 125 vans per day. To choose the production flows, the production chain is distributed following the order 1 sedan, 1 coupe, 1sedan, 1 van etcetera, and all the available resources will be displayed to launch a vehicle every 57.6 seconds. If the production must be increased or reduced from one month to another, the capacity or the labor schedule will be readjusted. As a result of this programming phase, the number of kanban cards to use will be calculated per month and element.

The third part of the product regularization is execution and stock control; this is essentially where the Toyota system has its particularities, especially by creating a physical connection between the different levels of the materials by putting into circulation two types of cards called required kanban and production kanban.

The JIT method has supposed some contributions that have been also implemented in other industries:

JIT Contributions	**Automotive Industry and other industries**
People formation	✓
Save resources and founds	✓
Better selection of few excellent suppliers	✓
Increase of the enterprise's adaptability to make changes	✓
Increase in workers satisfaction and enthusiasm	✓

2.4 PRODUCTION FIGURES EVOLUTION

Over time, the automotive sector has positioned itself as one of the most important sectors in developed economies. Over the last decades, the automobile has become the most important consumer good in economics and social life; it is a key sector for most countries in the world. The industry is considered an innovator, investing more than 74 billion in research, development, and production. The industry is capital intensive and knowledge-intensive, and it plays an important role in the country's socio-economic development, accounting for 5 to 10% of developed countries' GDP, and reaching percentages of 14%, 12%, and 10% in Germany, Japan, and South Korea respectively (Saberi, B. 2018).

In years to come, automotive companies in Brazil, India, and China are likely to continue to grow their share of the global market, while the rise of environmental concerns is likely to bring substantial changes in how the industry adapts and evolves in the future (Industria, C. C. O. O. 2018).

2.4.1 Production figures

2.4.1.1 Total Vehicles Production

According to the International Organization of Motor Vehicles Manufacturers (OICA), China is the world's largest producer of vehicles. In 2019 approximately 80% of China's production went towards making passenger cars, while the other 20% were for commercial vehicle use. However, the production during the last part of 2019 decreased in the number of completed vehicles, which might be attributed to the trade war with the United States. SAIC Motor Corporation Ltd is the largest manufacturer of vehicles in China.

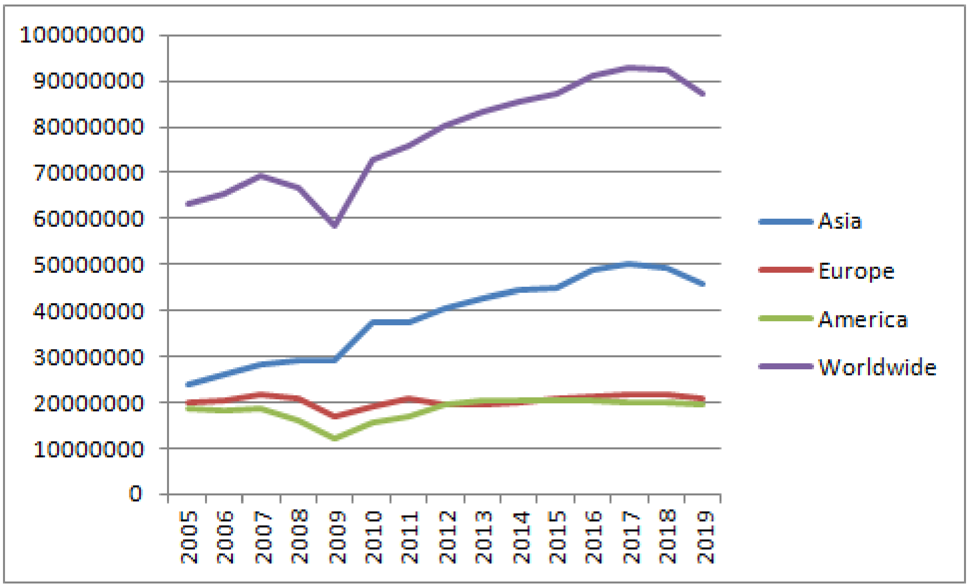
The United States of America is the second-largest car manufacturer in the world. Although its production of passenger cars was less than Japan and Germany, the country produced almost twice as many commercial vehicles as any other country. General Motors Company manufactured a majority of the automobiles manufactured in the USA. The continent has decreased its importance in the production of vehicles during the last years from 29.36% of the production in 2005 to 22.18% in 2019 (OICA)

Japan produced 8.3 million total vehicles in 2019, 9% of all vehicles made. Japan is responsible for the second-highest amount of car exports in the world. Toyota is responsible for approximately 29% of Japan's automobile manufacturing, while Honda Motor Company is the second-largest manufacturer, holding about 14.4% of the Japanese market, followed by Nissan Motors.

Germany produced 4.6 million total cars in 2019. This figure represented a 9% decrease from 2018 production levels. The dollar value of almost one-quarter of all cars manufactured in Germany is exported. Volkswagen AG is the leading German manufacturer, producing just under 700,000 cars among its many makes including Porsche. Mercedes Benz is the second largest manufacturer in Germany. BMW comes in third, which also owns the Mini and Rolls Royce brands.

India, while not well known in America or Europe, produced 4.5 million total vehicles in 2019, with 8% being personal cars. The largest manufacturer in India is Tata Motors Limited. Around 650,000 cars manufactured in India were exported.

Graph 1: Evolution of the total vehicle's production



Source: OICA

The total production of vehicles has increased year by year worldwide, except for the years 2008, 2009, and 2010 due to the financial crisis. The figures have increased from 63,228,032 vehicles in 2005 to 87,372,851 in 2019.

Asia is the continent with the highest importance in vehicle production; the territory has increased its importance in the sector every year, passing from a representation of 38.2% in 2005 to represent in 2019 the 52.6% of the total production. The country with the highest importance is China, which in the last year represented 50.8% of the total production of the continent; the second country with the highest importance is Japan with 19.9% of the total production.

Europe is the continent which has lost more importance during the last years, in 2005 Europe represented 31.7% of the total production, but last year this percentage decreased to 24%. The country with the highest importance is Germany, followed by Spain.

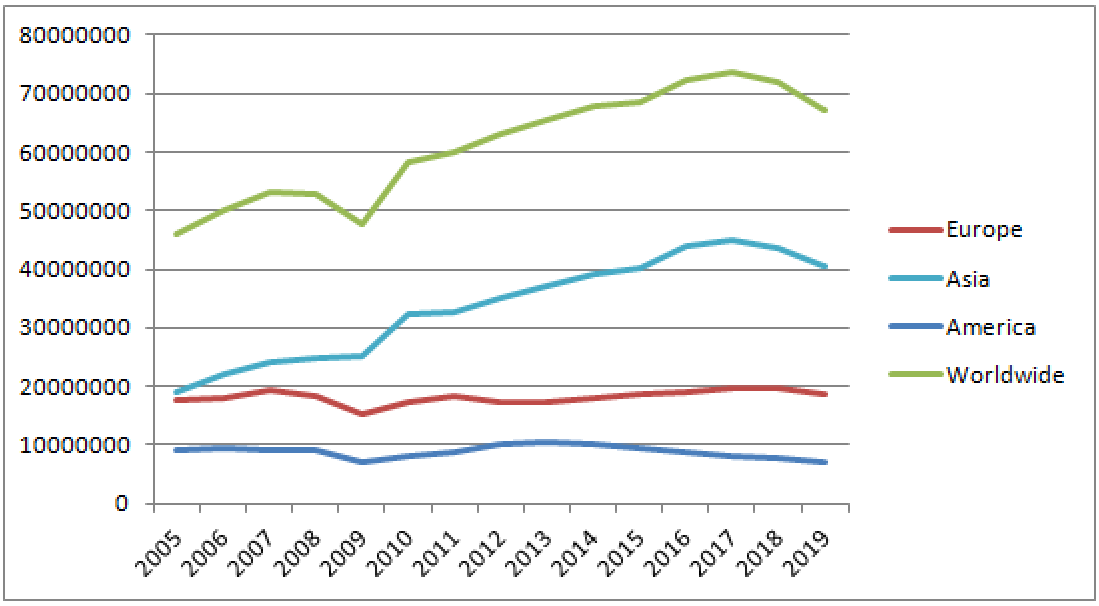
Finally, the production of vehicles in America has also lost importance but not as drastically as in Europe, the continent represented in 2005 29.36% of the total production while the last year was 22.18%. The country with the highest importance is the United States, which last year represented 54.3% of the total production. The second country with the highest importance is Brazil with 14.4% of the whole production.

2.4.1.2 Passenger cars production

The production of passenger cars has increased in the last 14 years from 46,008,847 to 67,149,196. The highest figure until now was registered in 2017 with 73,456,531, but in the last two years, the production has decreased mainly because of the pollution restrictions which entered in force in 2018.

The continent which produced more passenger cars in 2019 was Asia. The continent produced 40.666.078 cars, which represented 60.5% of the total sales. The evolution of the Asian continent has been positive during the last years, representing in 2005 the 41% of the total sales. It's important to highlight that the highest contributor to the continent's production is China. Last year, this country supposed 52% of the cars produced; the second is Japan, which represents 20.4%.

Graph 2: Evolution of the passengers' cars production worldwide



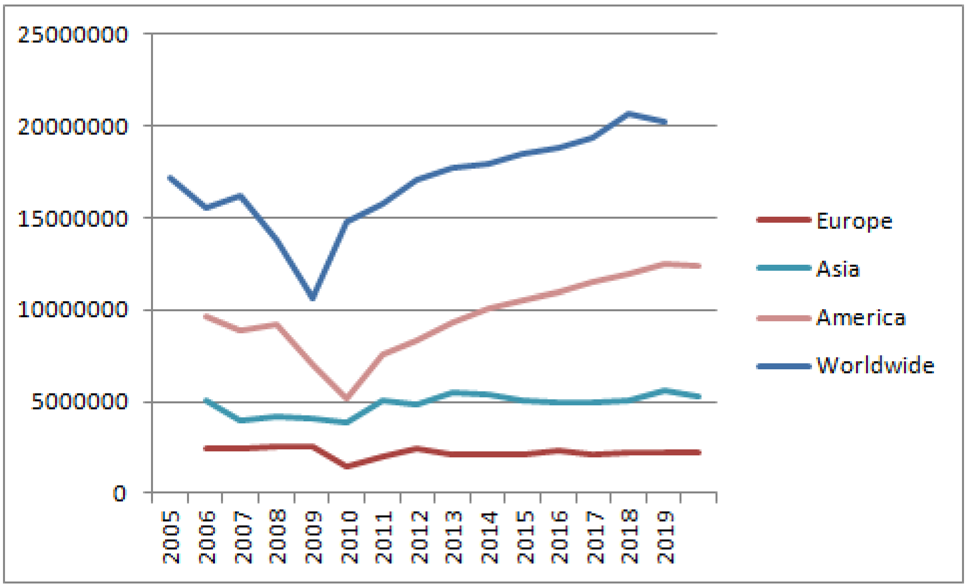
Source: OICA

Europe is the second continent in passenger car production, although its influence is decreasing year by year. Last year, the continent represented 27.8% of the total production while in 2005 it represented 38.3%. The country with a higher contribution is Germany, 24.8% last year, followed by Spain, 12%, and France, 8.9%. In the last years, European production is losing importance to Asia, the European continent has maintained a constant production but the differences with Asia have increased because of the acceleration of the economies and sectors with lower labor costs. The production increases have been favored by better positioning of the electric vehicle production in the Asian continent, achieving the 56% of the electric vehicle registrations in 2019. (El País, 2019)

2.4.1.3 Commercial vehicle's production

America is the leader continent in commercial vehicle production. Last year, the continent represented 61.3% of the total production in the world and they have been able to maintain or even increase the advantage over other continents. The country which more supports the production of the continent is the United States, which represents 64.5% of the whole production; the second country with a higher influence is Mexico, which supposes 19.2%.

Graph 3: Evolution of the commercial vehicle's production



Source: OICA

Asia is the second continent with a higher importance in commercial vehicle production. Last year, the continent represented 26% of the whole production and it has maintained its influence during the last fourteen years. The country with higher importance is China, which represented 37.9% of the production of the continent last year. The second country is Thailand, representing 23% of the production.

Europe is not a strong territory regarding the production of these types of vehicles. Last year the continent represented 11% of the whole production and this figure has decreased during the last years. The country with a higher influence is Spain, which supposed 23.2% of the production last year.

It can be seen that the three continents suffered a decrease in automobile production due to the financial crisis, but America was especially affected during this period.

Some of the reasons that explain the growth and the domain of Asia are these three aspects: Electrification, autonomous cars, and carsharing (La Vanguardia, 2019). The car's electrification will substitute fossil fuels; furthermore, the autonomous cars will be equipped with technologies that include radar and GPS that can help to detect the environment and the most suitable routes. China, the main Asian producer has launched a plan in which the development of intelligent vehicles is a national priority.

Another reason is that if a foreign brand wants to sell in Asia, it has two options: Its cars can have import tariffs or they can produce the cars in the country to obtain a good competitive price. The vast majority of car producers have chosen the second option. The legislation says that they have to be associated with existing manufacturers and create a joint venture. Due to these measures, different joint ventures appeared; some examples are SAIC/Volkswagen, Dongfeng/PSA, GIG/Peugeot, or TAI/Daihatsu.

3. THE CURRENT SITUATION

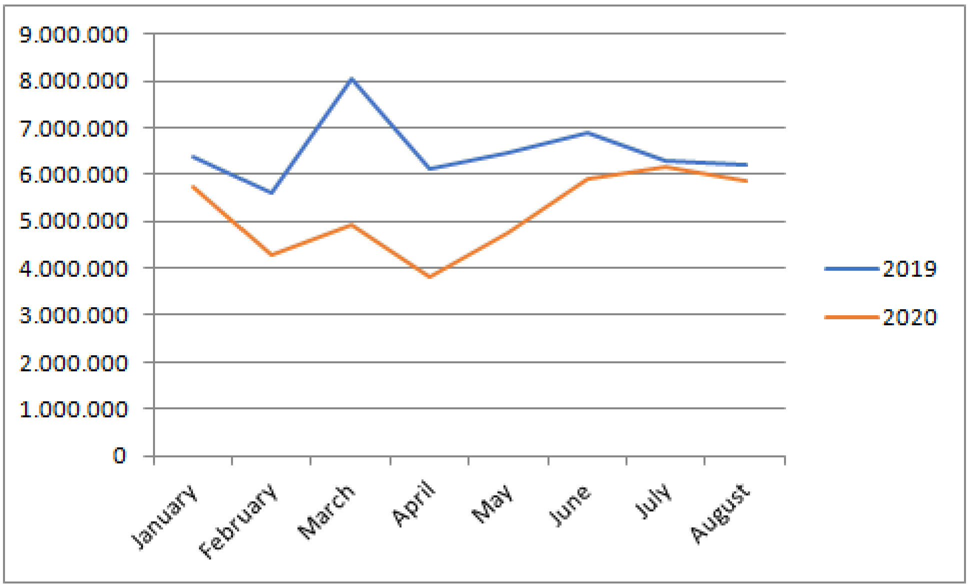
3.1 THE AUTOMOTIVE SECTOR DURING THE YEAR 2020

The present year has been shocked by an unusual situation, a global pandemic that has affected the entire world. This has meant different lockdowns in several parts of the world. The automotive industry is facing a heavy decrease in demand and investment. This sector is also being affected by the sudden and generalized stop of economic activity, with workers confined to their homes, immobilized supply chains, and closed factories. It is believed that travel restrictions and the sudden interruption of economic activity will lead to a sharp contraction in production and gross domestic product (GDP). It is estimated that factory closures in Europe and North America have forced the withdrawal of 2.5 million vehicle passenger transport programs of the production, suffering 77.7 billion US dollars in losses of income for automotive and parts manufacturing. (International Labour Organization, 2020)

According to the International Labour Organization (OIT in Spanish), this has negative multiplier impacts on the economy by the effects of drag and propulsion, in particular in countries such as Canada, Germany, China, United States, India, Japan, Mexico, Republic of Korea, and South Africa, where the automotive industry is an important driver of economic growth. The decrease in the demand for other services like transport, merchandise, or travelers will affect the automotive sector and in a near future, it might be possible to see an increase in commercial vehicle demand while the demand for passenger cars will be reduced due to the uncertainty which has been experienced.

The pandemic has generated an unprecedented increase in unemployment in all the supply chains of the automotive industry, and there is a risk of losing more jobs if governments, employers, and workers do not act immediately to enable the survival of Small and medium enterprises and protection of workers.

Graph 7: Sales of new vehicles in countries represented in OICA



Source: OICA

Variation of sales between 2019 and 2020

	2019	2020	VARIATION
JANUARY	6,374,173	5,737,591	-10%
FEBRUARY	5,602858	4,297,691	-23%
MARCH	8,064,294	4,920,918	-39%
APRIL	6,117,562	3,808,755	-38%
MAY	6,444,926	4,734,962	-27%
JUNE	6,887,312	5,911,081	-14%
JULY	6,314,118	6,153,883	-3%
AUGUST	6,194,172	5,857,286	-5%
TOTAL	51,999,415	51,416,167	-20%

Source: OICA

The new vehicle sales in China decreased by almost 92% in the first half of February in 2020 and it has been estimated that vehicle sales will decrease in china by at least 2.9%.

According to the European Association of Manufacturers of Automobiles, the new vehicle sales in the European Union in January and February were 7.4% less than last year. In 2020, the demand has decreased in the four principal European markets: Germany (9%), France (7.8%), Italy (7.3%), and Spain (6.8%).

Taking into account that China is the main supplier of intermediate inputs for enterprise manufacturing companies in other parts of the world, the decline in production and exports of China has a direct impact on the automotive industry.

For many automotive companies, the lack of stocks and the strong dependence on Just in Time manufacturing is generating breakdowns that affect the production capacity and total exportations (International Labour Organization, 2020). Taking into account those problems related to the JIT method, a transition to industry 4.0 seems to be clear. Talking about JIT and Industry 4.0 will suppose the transition to the digital transformation given that it arrives at the industry generating changes in the production processes and compromising the company's direction.

3.2 INDUSTRY 4.0

The desire of customers for greater connectivity with automobiles will bring important shifts in the automotive industry. The question then will be how industry 4.0 will shape the future of the auto industry. According to AP news, different factors will allow this change.

Firstly, the Monitor Predict Efficient, which is related to Big Data, will help to determine the causes of production failures. Predictive analytics can help to identify inefficiencies in the process with the objective that timely actions can be taken. This application of the IoT will supposedly be an important help for the automotive industry given that it prevents quality failures. For auto manufacturers, it is better to be predictive than reactive. Furthermore, real-time data will help manufacturers with inventory management, asset utilization, and reducing operational downtime.

Secondly, Industry 4.0 will offer benefits to make the supply chain more agile, IIoT will have unique advantages in the automotive industry ensuring the connectivity of every part of the supply chain. Suppliers and OEMs will achieve agility by adapting to the changing standards.

Finally, Industry 4.0 will allow customizing individual vehicles and minimizing the delivery time for those vehicles. IIoT will allow personalization as well as choosing the dashboard and the steering wheel, furthermore, with the introduction of industry 4.0 the idea of driverless cars has turned into reality.

The application of the Industry concept in the automotive industry will affect manufacturing processes so that the producer's value chain will change from design to the after-sale service. The processes will be optimized through integrated IT systems by using IoT along the value chain, as a result, today's manufacturing lines or cells will be replaced by fully integrated and automated production lines with industrial or collaborative robots. By implementing the use of robots and smart products and machines that will interact and take decisions between each other, the process's manufacturing flexibility will increase. Products, processes, and production automation will be designed and represented visually in an integrated process, and through supplier collaboration; the physical prototypes will be reduced to a minimum. The logistics will use autonomous vehicles and robots, so it will become logistics automated as it will be automatically adjusted to production needs (Wagner, T., Herrmann, C., & Thiede, S. 2017).

According to Edgar Daniel Oliva, the application of industry 4.0 in the automotive industry will affect the production processes producing the change of the value chain from the design to the post-sale service. The production processes will be optimized through IT systems that will be integrated using the IoT along the value chain. The result will be that the production cells will be replaced by total integrated production lines with industrial or collaborative robots. Thanks to the introduction of intelligent machines, the flexibility of the production process will increase.

Product processes and product automatization will be designed virtually in an integrated process and with the collaboration of the suppliers; the physical prototypes will be reduced. Machine Learning will allow the self-optimization and parameter adjustments of the manufacturing processes. Finally, logistics will use autonomous vehicles and robots to create an automatized logistic that will be adjusted to the production necessities (Oliva Navarro, E. D. 2018).

Technology causing the transformation of the automotive sector is called CASE (connectivity, autonomy, shared mobility, and electrification) technologies. Each technology has started to affect the sector in many ways and their convergence will have an important impact on the automotive value chain. It means that during the next decades some OEMs will fall behind the technology innovation curve due to their substitution by larger suppliers or they will simply close their doors. Therefore, to remain relevant in this new technology period, companies in the automotive ecosystem are investing in product manufacturing and process innovation. Some manufacturers are looking to competitors for opportunities to reinforce their technology portfolio. Other companies are searching for digital transformation initiatives to increase the efficiencies in the manufacturing process, investing in technology solutions like smart factories, cobotics, or digital supply networks. Nevertheless, focusing on the technological solution could not be enough and the global automotive industry will require a reinvention of all the aspects of the business, including the manufacturing process, the business model, and the customer experience. The transformation will be only achieved when the digital technologies will be connected with an integrated organizational design.

As can be seen, to succeed in the innovation era the automotive companies will have to take advantage of a variety of advanced technologies. This digital throughput across the entire value chain will generate tons of data in real-time, then, companies that will be successful at capturing and analyzing the data and information will unlock exponential growth to accelerate the innovation curve. The implementation of these technologies will suppose a set of challenges like the shortage of talent to plan, execute and maintain new digital systems. The number of engineers handling big data is gradually increasing but it does not fulfill the demand (Deloitte, 2020)

The quickest way of ending any emergent transformation will be the company's inability to articulate its value to management, investors, and employees.

The 4.0 industry, despite it was created in the Automotive Industry (Oliva Navarro, E. D. 2018), has been implemented in other industries:

Industry 4.0 contributions	**Automotive Industry and other industries**
Set up times, labor and material cost reductions	✓
Vertical and horizontal integration	✓
Remote process monitoring	✓
The manufacturing process is more efficient	✓
Increase in the product quality	✓

3.3 CURRENT SUPPLY CHAIN MANAGEMENT ISSUES

3.3.1 GENERAL OVERVIEW

According to Fernando Gomez Brezueta, who wrote the essay *"Analysis of an auto part supply chain,"* a car is composed of approximately 15000 pieces. It is important to take into account that only some of these parts are produced directly by the car brand, other pieces are manufactured but direct suppliers that at the same time can have other suppliers. In the automotive supply chain exists a group of companies that create the strategic plan for the production cycle creation, this process starts with the supply of the raw materials and ends with the final product delivery, the vehicle (Merchán, M. V. N., & Berrezueta, M. F. G. 2018).

The suppliers will be classified according to the distance with the Original Equipment Manufacturer (OEM).

The first one is the tier 1suppliers, which are the most important components in the supply chain. A Tier1 supplier provides what the OEM needs in making the product and setting up the chain. Often, they will supply powertrains, suspensions, chassis, and entire engines to OEMs. In some cases, Tier 1 suppliers can manufacture up to 99% of a whole vehicle, becoming OEMs themselves. Some examples of Tier 1 suppliers are Magna, Bosch, Continental, Denso, or Hitachi.

Tier 2 suppliers arise as a consequence of the success of the front line Tier 1 supplier, which allows the introduction of second-tier suppliers that produce smaller pieces of the components that the Tier 1 suppliers sell to the OEMs. Some examples might be car window motors or door handle mechanisms of heat exchangers. Tier 2 companies are typically not focused solely on auto parts. Some examples of Tier 2 suppliers are USCO, Minth Group or Zexel

Tier 3 suppliers will provide the most basic components needed to make cars, for instance, specific cars (individual switches or cables) or a piece of engineered material, like a large section of glass or steel.

3.3.2 SPECIFIC VIEW

3.3.2.1 Integration

Supply chain integration is a concept that refers to the level of cooperation between partners and to achieve efficient flows of products and services to the final customer (Delic, M., Eyers, D. R., & Mikulic, J. 2019). Many companies have adopted innovative solutions for supply chain management to improve services and delivery quality because of the global pressure and changes in production occurring in recent years. In the automotive industry, this supposes a transformation from closed and technically oriented production toward open and collaborative innovation. This approach has generated a redesign of the business process to achieve supply chain integration (Bennett, D., & Klug, F. 2012). The new model also supposes to improve the relationship between the OEMs and the Tier 1 suppliers.

The internal integration of the supply chain is focused on how to integrate and synchronize the different procedures of the firm. Additive manufacturing, which consists of an approach to industrial production to enable the creation of lighter and stronger parts and systems, will be one of the factors that can promote the integration in the supply chain thanks to the design and production. This concept can be used to increase the importance of the digital inventory that will help to attend to the demand inside factories. Nevertheless, Additive manufacturing can also improve the data flow between departments or support vertical integration in an organization. Additive manufacturing is seen as a disruptive technology given that it can reduce warehouse space, transportation costs, and include faster deliveries. This technology will provide the industry with the possibility of reconfiguring the supply chain given that manufacturing points can be closely located to the demand points. But it is also important to keep in mind that Additive manufacturing is facing some limitations and is only used with prototypes or scale models (Dwivedi, G., Srivastava, S. K., & Srivastava, R. K. 2017).

Improving supply chain integration will have a positive effect on supply chain performance. Integrating Tier 1 suppliers in the early phase of the supply chain activity will have a positive effect on the performance of vehicle manufacturing in terms of costs and quality. (Delic, M., Eyers, D. R., & Mikulic, J. 2019).
There are different philosophies in the automotive industry under which the supplier's integration can be seen. The technological perspective is related to the aspect of the product, its development, and its manufacturing process. The supply perspective is related to the competitive strength of the subordinate structure. Especially JIT, build to order and modular supply chain have an important role in the automotive industry (Bennett, D., & Klug, F. 2012). The traditional way of exchanging orders has been also replaced due to information technology (IT) and electronic data interchange (EDI). EDI is a technology used for the exchange of information and data across the organization.

To understand the different forms of logistics supplier integration, it is important to know the factors that contribute to the integration; these factors can be divided into four conditions that will characterize the integration in the automotive industry.

The first condition is geographical proximity. The high complexity of modern cars had made vehicle makers (VMs) not necessarily have the knowledge and experts to build modern cars entirely. For this reason relationships with suppliers are required. This supplier proximity will improve the conditions for the exchange of work between the VM and the supplier. The establishment of co-located suppliers will suppose quicker problem resolution, rapid transfer of knowledge, and better mutual understanding. The main advantages will be the reduction of inventory, transport costs, and lower capital and working costs. (Bennett, D., & Klug, F. 2012).

The second condition is formed by delivery contents, volume, and sequence. The growing variant number of individual vehicles has supposed the increase in the parts required by the assembly plants. To solve these problems Sequenced in-line supply (SILS) is needed. It requires that suppliers must deliver components and modules in the same sequence and synchronized with the assembly line process. SILS must be accompanied by modularity, which means that the car will be divided into less complex modules. The modular system will reduce the number of Tier 1 suppliers needed to coordinate the complexity of the final assembly. (Bennett, D., & Klug, F. 2012)

Information sharing and IT system integration for the third condition. Higher integration of suppliers will mean higher importance of information sharing. Visibility in the supply chain using electronic integration will be really important for the search for competitive advantage. IT integration will allow vehicle manufacturers to share logistic information in real-time. (Bennett, D., & Klug, F. 2012)

Finally, the fourth condition is formed by the transport system: The role of the traditional transportation system has changed due to the coordination of physical flows between assemblers and suppliers. Co-located suppliers can group the goods transported, this will reduce transport costs. The frequencies and type of transport change depending on the types of logistics. For instance, in the modular case, transport is not needed in general. The longer and heavy the transportation is, the more likely it is to use heavy goods vehicles. (Bennett, D., & Klug, F. 2012)

3.3.2.2 Collaboration

The automotive industry is gaining a high level of competitiveness due to different factors like nature of products, nature of models, and customers requirements, this level of competitiveness has supposed a review of the existing strategies using lean manufacturing (Ibn El Farouk, I., Moufad, I., Frichi, Y., Arif, J., & Jawab, F. 2020), which is a method focused in the continuous improvement and optimization of the production system through the elimination of waste and activities which do not add any value to the production process. Another aspect that has gained a lot of importance is the synchronization flow due to the increasing complexity and diversity of components.

Despite the importance of lean manufacturing, it is not sufficient to gain full competitive advantages. The lean methods need to be extended to the auto component suppliers. For this reason, collaboration has been identified as one of the main factors for the successful implementation of lean tools and practices in the supply chain. A close relationship between suppliers and manufacturers will lead to risk sharing, reduction of transaction costs, and supply chain resilience over time (Huang, Y., Han, W., & Macbeth, D. K. (2020). In the automotive industry, some important drivers of collaboration are information sharing, joint decision making, or electronic data interchange. (Al-Doori, J. A. 2019)

Some effective collaborative factors will allow carrying out lean activities in the automotive industry. Collaboration with suppliers will be one of those factors given that it can improve the company's performance and it also supposes an opportunity to gain a competitive advantage (Boonsthonsatit, K., & Jungthawan, S. 2015, May).

Training is another important factor given that it has been proved that training increases the application of lean tools and structure the way of working for continuous improvement.

Resources will make some companies collaborate with experts to implement lean supply practices, which means a center that resources to work with these experts are really important.

Proximity will be the last factor. It is challenged by geographical dispersion, for this reason, suppliers with proximity are perfect candidates for JIT delivery.

The fast growth of the production supply chain requires the interconnection between stakeholders given that different studies have shown that SC collaboration increased the performance of the industry.

Information sharing (IS) is going to be an important tool given its usefulness to increase the efficiency of the whole network and enhance the firm and operational performance (Al-Doori, J.A., 2019). IS will include logistics, customer quality, or time market change. It will have many positive effects on performance but it will be also a good tool to decrease uncertainty.

Electronic Data Interchange (EDI) will be another important tool given the fact that the Internet has made it possible for partners in the supply chain to act with the same data and with the minimum time. EDI will provide the needed visibility to data across the supply chain network, process manager applications, and server to server links that allow true and real-time channel information (Al-Doori, J.A., 2019). This degree of collaboration will increase communication to facilitate joint operations and coordination (Pope, E., Brown, R., Johnson, D., & Rocker, J. 2011).

3.3.2.3 Flexibility

Supply chain flexibility (SCF) is the result of the enormous contribution that the supply chain makes to the competitiveness of the whole organization. The automotive industry represents a demanding industry that has suffered a huge variety of changes since Henry Ford’s approach. SCF is considered a tool to respond to the rapid changes in the industry without incurring excessive losses (Delic, M., & Eyers, D. R. 2020).

Since technological change is one of the higher difficulties that must be faced in the industry, achieving SCF is a key capability to deal with this problem. One of the ways to improve flexibility is the acceleration of product design and production, given that it allows companies a quick variation in production and production mixes. Another point to be taken into account is the increase in the requirement of custom products by part of the customers, which means that automotive manufacturers must expand the range of products offered (Alford, D., Sackett, P., & Nelder, G. 2000).

To achieve flexibility, Additive manufacturing allows manufacturers to satisfy the market demands (Weller, C., Kleer, R., & Piller, F. T. 2015). Given that it allows a cost-effective adaptation of the production process, fast product and process configuration in the supply chain, new product development, and performing difficult design geometries. In the automotive industry context, some companies like BMW used additive manufacturing to make hand tools and the result was a save in the cost of 58% and a project time reduction of 92% (Delic, M., & Eyers, D. R. 2020). The use of additive manufacturing allowed Mini, which is a BMW Group brand to offer to their customers' different online services like custom inlays before using additive manufacturing and include it in a personalized vehicle (Additive news,2018), nevertheless, a few numbers of companies use this method. In automobile production, the main point is the avoidance of failures that can arise due to poor design and production or the inability to respond to customer needs (Delic, M., & Eyers, D. R. 2020), for this reason, automobile companies produce prototypes using computer design to reduce the product configuration time.

The SCF can improve the competitiveness of the company in different fields, especially in the decision-making process of applying new technologies (Sánchez, A. M., & Pérez, M. P. 2005). Nevertheless, some managers do not have a complete vision of flexibility and they are focused only on machine flexibility without taking into account the flexibility of the entire system. The need for product differentiation in the automotive industry has supposed the introduction of new production methods, new parts, and new designs. An important ability for the industry is the capacity to produce different types of products directly from the raw materials given that it will allow companies to predict production difficulties.

Given that the automotive industry is characterized by a constant pressure to create relationships with key suppliers, the inclusion of these suppliers in the first parts of the product development will improve flexibility and reduce product development time and costs. Additive manufacturing allows the first supplier involvement in the component and finishing product design. Original equipment manufacturers (OEM) and suppliers use additive manufacturing to support the decision-making process; this helps the OEM to create the tier 0.5 suppliers, which are those suppliers that will collaborate to achieve faster changes and innovations for automobiles

A flexible supply chain will allow the quick placement of new and existing products in the required quantities and it will also enable flexibility in the delivery process.

3.3.3 Specific cases

This part of the research has been obtained from the document "*Supply Chain Management of Mass Customized Automobiles"*, which has been written by Arshia Khan.

3.3.3.1 Mercedes-Benz Supply Chain

Mercedes-Benz has been focused on the reduction of vertical integration, as a result, the company operates around the world but the mainly assembling plants are located in Europe. The company has achieved a highly integrated supply change; nevertheless, they are still introducing the modular approach to get in long term relationships with suppliers. The company believes in a policy of few but reliable suppliers, some of the suppliers are ThyssenKrupp AG or Eagle Ottawa GmbH.

Mercedes-Benz has a huge amount of variants, which implies an increase in the flexibility and complexity in the working environment. These characteristics have made the company must be focused on lean production to reduce inventories, assure the supply of materials, and secure the time deliveries.

An important point in the company is the modular approach, which has reduced the work in the plant given that large production modules (cockpit, steering column etcetera) are transported as a single unit form from the suppliers to the plant. This strategy supposes less investment and less risk.

Given that almost half of the R&D investment is related to green technologies, the company has needed to outsource some functions. It is extremely necessary to determine what will be done in house and what will be outsourced. According to the company, the architecture development and the safety features will never be outsourced, nevertheless, many departments and engineering can be outsourced.

3.3.3.2 BMW

BMW AG has a highly developed system with a flexible production line to develop customized vehicles. Furthermore, the company uses the "Customer-Oriented Sales and Production" program, which allows them to produce a customized vehicle in 12 days. 50% of the BMW production is located in Germany.

The German company has a close relationship with many suppliers and they rely on them for the innovative process and new product development. These suppliers are located close to BMW plants to provide the JIT method. BMW AG has carried out a huge automatization. When a customer makes an order, the system will determine which factory will build that order depending on the availability of materials. For this method, the company uses the SAP system to manage inventories and production statuses. This system will help to reduce the delivery time for the car.

One of the differences with MERCEDES-BENZ is the number of suppliers, BMW AG has 12000 suppliers from 70 countries, for this reason, the company has a specialized department to integrate different aspects like environmental standards comfortably. The company also uses the supply center system, BMW has developed its site and all the suppliers and providers are tenants. Given the proximity of the suppliers, the late module configuration is possible using the JIT. Transforming the supplier into a tenant and not the owner of the site will increase the control of the company over its suppliers.

The company has also carried out an outsourcing strategy; one example is the car seats. When the order is received, BMW sends the order to the supplier according to the selected specifications and the order arrives at the assembly line 90 minutes before the final assembly. Suppliers are located near the assembly lines. BMW AG uses the 3 content delivery network (3CDN) to increase the speed of the information flow between Munich (Main headquarter) and the 4000 dealers which are distributed around the world, with the 3CDN the company will ensure maximum availability all the time.

3.3.3.3 Volkswagen AG

The company is one of the pioneers for mass customization. Given the large amount of production which is carried out in Volkswagen, the company has to deal with longer lead times in mass customization.

Volkswagen Ag uses a decentralized and vertically integrated system. All the brands of the company are considered individually; however, they share the platforms inside the company, which gives to the company a competitive advantage. The logistic system in plants has increased the efficiency of the company; some examples of the improvements which have been achieved thanks to this technique are the elimination of several errors in the manufacturing system and being able to cope with high production volumes. The system previously mentioned is called “Ride along with the platform” before its implementation workers had to pull the parts to be assembled.

The Supply Chain of the company is an integrated process that has achieved dynamic changes in the supply system because of different methods like the FAST program. This program tries to cope with the challenges of modular production, for this reason, Volkswagen analyses every supplier and selects the ones who are efficient enough to face these challenges. Concerning the supplier’s location, the Supply Centre concept has been used by the company to get the supplier near to the assembling line.

The Supplier’s contribution to the value-added of the company is lower than in BMW or Mercedes. The company has an important affinity for in-house operations and since several years ago has carried out investments to implement this technique instead of starting with the development of outsourcing as other companies.

3.4. TENDENCIES IN THE SECTOR

The main tendency of the automotive sector regarding the future of the industry is sustainability. In the automotive sector, sustainability has particular importance given that the members of the industry have to comply with the environmental standards and meet the social requirements but at the same time, they have to maintain a competitive level in a sector that is characterized by fluctuations in the customers demand and the constant changes in the regulations. The environmental challenges and government policies have forced the automotive firms to incorporate sustainable Supply Chain Management (SSCM) in their activities, which has helped to reverse the adverse effect of the industry and has implemented the use of environmentally friendly practices to improve the profitability of the business (Mathivathanan, D., Kannan, D., & Haq, A. N. 2018).

The sustainable performance will imply some changes in the traditional supply chain structure which will be linked with a set of challenges. Competitive pressure is being intensified given that low-cost manufacturers can undermine European leadership. Another important question is the availability of future resources (Sukitsch, M., Engert, S., and Baumgartner, 2015).SSCM practices must be followed by two principles. The first one is the promotion of ecological health and the improvement of economic vitality. The second one is the prioritization of the environment first, society second, and economics third.

Supply Chain Orientation (SCO) will be an important tool to achieve sustainability. Given that SSCM is based on SCM concepts and in sustainability performance, the supply chain performance perspective makes a logical connection with the SCO, which can be defined as “the recognition by a company of the systemic, strategic implications of the activities and processes involved in managing the various flows in a supply chain” (Esper, T. L., Defee, C. C., & Mentzer, J. T. 2010).

SCO can be considered an organizing influence that has focused its effects on internal organizational capabilities such as sustainable practices. The organizational SCO will design an organizational culture that can control the structure of the organization and achieve the supply chain goals (Lee, T., & Nam, H. 2016).

One of the primary objectives of the automotive supply chain is to be sure that vehicles arrive at the end customer under good conditions, but on the other hand, it is important to be sure that the end life vehicles are recycled properly and can be reabsorbed into the manufacturing process. For this reason, the supply chain must be extended to include recovery operations like remanufacturing or recycling.

Then, the first part of the chain will be related to the vehicles that must be delivered to the customer and the second part will be related to the reabsorption of the used vehicles. According to Olugu, the complexity in green supply management will be related to the uncertainties associated with the replacement/recovery process and the reverse process itself due to the transportation of use products. Adopting the proposal of the two chains these problems can be minimized. The first chain will be the forward chain and the second one the backward chain.

The forward chain must assure that the product is green enough and satisfies the customer's needs. Then, the performance measurement should quantify how green the process of making and delivering the vehicles is.

Regarding the backward chain, it begins with the customers and flows to the collection center, then to the recycling center and from there the recycled materials go back to the supplier to make them available for the manufacturer. Another possible scenario can be the manufacturer collecting the material directly from the recycling center and integrating it into the manufacturing center (Olugu, E. U., Wong, K. Y., & Shaharoun, A. M. 2011).

Another important factor to achieve the sustainability of the supply chain is the supplier commitment to the greening exercise. For this purpose, according to Olugu there exists different metrics. The first one is the supplier environmental certification. According to this factor, the selected suppliers must be recognized as practitioners of green sourcing and supplying.

The second factor is the level of supplier performance and sustainability. This Measure can be done periodically to reassure the commitment to the greening exercise.

Other measures are useful to identify the internal operations of the company to achieve an environmentally supply chain. Some of these measures are the level of process management and the availability of process optimization for waste reduction. The first one will consist of the level of optimization and modification of the processes to reduce the environmental impact. The second one analyses whether the company has a structure to reduce the waste generated during the manufacturing process.

It can be concluded that Industry 4.0 and the circular economy can be considered the future of the organizations due to the rise in automation and reverse logistics practices that will allow achieving global sustainability. According to Oliveira, some 4.0 Industry factors like the integration of digital and physical systems or the adoption of advanced machine learning algorithms have the objective of promoting digitalization and developing smart systems that can develop sustainable resources to obtain a green future.

Suppliers are also considered as an important part to achieve sustainability, for this reason, will be important to have a positive commitment from them for delivering recycled materials. Furthermore, the digitalization of supply activities will optimize outputs thanks to the removal of waste and nonvalue added additives (Yadav, G., Luthra, S., Jakhar, S. K., Mangla, S. K., & Rai, D. P. 2020). Educating the customers for recycling practices will be another important aspect given that with the right recycling practices the manufactured products will not harm the environment.

Regarding the circular economy, the adoption of the 6R's (Recycle, reuse, reduce, refuse, rethink and repair) will be directly linked with sustainability. As previously said, recycle is related to the re-processing of a car to be used in a new one. Reuse refers to the use of the materials or parts of a waste product in a new one, reduction consists in minimizing the material and energy used in the production life cycle. Refuse will consist in rejecting the product if it is not required or if it is not sustainable. Rethink refers to finding alternatives for the optimization and finally, repair consists of finding the measures to fix any problem (Yadav, G., Luthra, S., Jakhar, S. K., Mangla, S. K., & Rai, D. P. 2020).

4. CONCLUSIONS

This work has analyzed the evolution of the automotive industry and its operation management from the first years of car production until the present situation. To do the analysis, it has been carried out a study of the production figures in the industry during the last 15 years and a bibliography recompilation to explain the evolution of the industry.

The work has been divided into two parts. The first one has explained the evolution of the industry including the beginning of the industry, Henry Ford's supply chain method, the adoption of the Just in Time method, and the evolution of the production during the last fifteen years. The second part of the work has explained the current situation of the sector, providing figures about the production of the year 2020 and explaining how industry 4.0 is being adopted in the industry. The work will finish with the tendencies of the automotive industry in terms of sustainability.

In the modern age, the development of the economy of any country cannot be imagined without the development of the automobile industry. The contribution of the sector to the GDP structure is increasing and this dynamic will create new jobs increasing at the same time the average wage. The automotive industry contributes to the revenues of the state budget, develops auxiliary branches, and influences scientific and technical progress. Then, the correct functioning of this industry will be relevant in the economic field but also the social one (Saberi, B. 2018).

Fluctuating market demand or customer requirements will be key challenges in the automotive industry given that customers are more demanding and the variety of cars is an increasingly complex challenge. To maintain and improve the level of efficiency, quality, and costs, the automotive industry will have to search different areas to streamline its operations.

When it comes to adopting the latest technology, the automotive industry has always been at the forefront. From Henry Ford's introduction of the assembly line to the development of electric cars, the car industry has experienced different innovations. At this moment, the industry is facing the introduction of industry 4.0, which is ready to reshape the industry. Although the automotive industry has already adopted industry 4.0, many companies have not completely taken advantage of the technology. Considering the potential of the IIoT, it is expected that in 2022 more than 25% of the plant will turn into smart factories (AP News, 2020)

If industry 4.0 is understood as the digitalization of the whole product lifecycle, it has the capacity of creating a revolution in the automotive industry. The information backbone of industry 4.0 can reduce problems at the company level but also between different departments. This will have two major effects. The first one is that complex products can be analyzed as a whole. This will allow understanding relationships and optimizing the product and its production for an individual customer's needs. Secondly, the created product, related to its development, production, and environment, can automate decisions and act more proactively in its environment (Armengaud, E., Sams, C., von Falck, G., List, G., Kreiner, C., & Riel, A. 2017, September)

The new tendencies in the sector will mean significant changes and the implementation of Industry 4.0 in the,e facilities will change the manufacturing models. The creation of departments within the organization will be one of the key factors to achieve the implementation of Industry 4.0. These new departments will be in charge of managing, analyzing, designing, and implementing all possible changes to be made to achieve the full integration of the factory. It will be necessary to standardize the different systems and the resources needed to facilitate the integration in all the factories of the company.

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