



COVID impact in the transportation element of the supply chain of automotive industries.

Paola Montserrat Olin Delgado

Haaga-Helia University of Applied Sciences

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Abstract

Author(s) Paola Montserrat Olin Delgado
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Report/Thesis Title COVID impact in the transportation element of the supply chain of automotive industries.
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<p>This thesis explores the outbreak of the COVID 19 pandemic, and its impact on the automotive industry. More specifically, this research will focus on how transportation was affected and how it, in turn, disrupted the entire supply chain of automotive companies. The paper includes an analysis of both quantitative and qualitative data, questioned in a survey of professionals who experienced the height of the pandemic.</p> <p>The results of this thesis show how different areas have changed for the better and for the worse. It shows how technological advances had to be forced from the crisis, as well as the repercussions it brought with it. We will also cover ideas proposed by the interviewees themselves, where we will explore opinions for future phenomena such as COVID 19 and its impact on society.</p> <p>The motivation comes from the author himself, belonging to the demographic sector that this thesis studies. It is hoped that the results will help future generations that reach such critical points.</p>
Key words Logistics, Transportation, Coronavirus disease (COVID-19), Technology Integration, Supply Chain, Automotive industry, Adaptation Strategies.

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1 Introduction

The COVID 19 pandemic had a significant impact on the transportation of automotive industries in 2020. The restrictions and disruptions caused by the pandemic affected the entire automotive supply chain, from sourcing raw materials to manufacturing and distribution. The industry had to quickly adapt and implement strategies to mitigate the challenges and ensure the continuity of operations.

Lockdown measures and travel restrictions imposed by governments around the world posed significant challenges for the transportation of auto parts. The closure of borders and limited international flights disrupted the global supply chain, making it difficult to procure necessary components for the automotive industry. Additionally, the reduced demand for automobiles during the pandemic further complicated the situation.

To overcome these obstacles, the automotive industry implemented various strategies. Many companies focused on localizing their supply chains to minimize dependence on international sources. This involved establishing partnerships with local suppliers and manufacturers to ensure a steady flow of auto parts. Moreover, the industry embraced digital technologies to facilitate remote collaboration and communication between different stakeholders.

Efforts were also made to optimize inventory management and logistics. Just-in-time manufacturing and lean practices were employed to reduce inventory levels while maintaining efficient production. Additionally, alternative transportation routes and modes were explored to navigate the disruptions caused by the pandemic.

Analyzing the effects of the pandemic on the transportation of automotive materials provides valuable insights into the resilience and adaptability of the industry. By examining the strategies employed during these challenging times, we can gain a deeper understanding of how the automotive sector coped with unprecedented circumstances and identify areas for improvement in future disruptions.

1.1 Background

The author wants to implement and search for consequences on the transportation element on the supply chain of automotive parts, after working in a supply chain field and noticing the changes that their company had to do in order to keep up with the activities. This thesis is going to cover the effects that COVID had in the industry's supply chain, specifically in the transportation subpart.

The whole world has been affected by the pandemic that we all experienced in 2020, including one of the most impressive echelons in such an important chain, the auto parts industry. The effects that the virus caused went from big losses of raw material to sophisticated technological development. Therefore, the researched is based in finding the small new actions turned into big changes in what we know today as agriculture in the supply chain.

Then what is it that becomes too interesting to research about? The changes that were made had big impacts on the economy of several developing countries, whose primary economic activity relies on the production of raw material for big industries. Getting to know the reasons and the consequences that at the same time caused a bullwhip effect, is the primary motivation for the author.

Researching about different causes to the consequences can bring to the thesis a perspective of not only impacts in the transportation element of the supply chain, but to the global economy. The expected outcome of this thesis is helping other industries an idea of how to overcome different critical situations, helping to develop the career and strengthening its knowledge on the vast experience in the field of the author. Adding global situations and understanding of big companies is added value to students and employees or entrepreneurs.

It should be considered that the main objective of the author is to develop a complete thesis under a strict regimen imposed by themselves, so that the maximum effort will be given despite any obstacle that may arise, considering the quality of the content.

As mentioned before the author expects to obtain knowledge on the field, they're specializing in. Supply chain encloses several fields in which the author is interested. The automotive supply chain industry is one the topics the author is most interested in. Focusing on the transportation element trying to research the possible causes on the consequences helping companies to develop future against new crisis that could pose a threat. The international nature of this paper will be focusing on the transportation set in United States to Mexico and the impact of their delays in the North American economy and stock of raw material.

1.2 Research Question

Automotive Industry is one of the most important sectors that are the livelihood of many families in developing countries, however in the pandemic it became a very vulnerable sector and that is why the objective is based on understanding the causes of the consequences it had the pandemic in the supply chain as part of an analysis.

RQ. How did COVID affect the transportation element in the supply chain of the automotive industry?

1.3 Investigative questions

- **IQ1.** What are is the role of transportation in the supply chain of an automotive industry?
- **IQ2.** How big was the impact due to the breakdown in the transportation of the supply chain?
- **IQ3.** What are the technological advancements in the transportation since COVID?

Table 1. Overlay Matrix (Author 2023)

Investigative Questions (IQs)	Theoretical Framework ¹	Methods	Data Analysis/ Results
IQ1. What is the role of transportation in the supply chain of an automotive industry?	2.1, 2.1.1, 2.1.2	- Qualitative and Quantitative surveys to business professionals on the field topic - Desktop Research	-
IQ2. How big was the impact due to the breakdown in the transportation of the supply chain?	2.2	- Qualitative and Quantitative surveys to business professionals on the field topic - Desktop Research	-
IQ3. What are the technological advancements in the transportation since COVID?	2.3, 2.3.1, 2.3.2, 2.3.4, 2.3.5	- Desktop Research	-

1.4 Demarcation:

The research will be focusing on the effects of the COVID-19 pandemic on the transportation element on the supply chain of automotive industry, specializing on the northbound transportation (export raw material from Mexico to the USA), where the main producers of raw material for this industry is found. This thesis will analyze the consequences of this economic global crisis, but the boundary will stop the research when the content starts to include other countries of the automotive industry trade or that includes several countries in the other areas of America. The author decided to set these limits to focus on one element of the supply chain of the aforementioned area as

this is their main research field. The paper pretends to do not be ambiguous and can help readers to develop centralized ideas.

1.5 International Aspect

The present work is developed in the international aspect of the export and import of automotive goods, being one of the most globalized industries nowadays. The author wants to focus on the country where he resides, being one of the most booming countries for the industry of the century, being Mexico the 7th among the countries with more vehicle production in the world. The paper will focus on the transportation of goods both from the United States to Mexico and from Mexico to the United States. It is expected that the research of these countries will provide a clear picture of how COVID affected the supply chain of an industry as large and important to the economic sector as the automotive industry.

1.6 Benefits

The purpose of this paper is that the automotive sector will benefit as part of the research, being that the results can provide an overview of the crisis such as the COVID in the economy and various industries, focusing on the repercussions that existed when the phenomenon had its appearance. The author will also benefit from being part of the industry by understanding what were the consequences of the pandemic and the changes that arose in the supply chain, thus facilitating the recognition of factors that influenced, for future critical situations that may arise.

1.7 Motivation

he motivation for writing this paper comes purely from the author's interest in understanding the landscape that emerged when the COVID phenomenon occurred in the area in which she is currently working. Thus, including the consequences that directly affect her as she is part of the industry being researched, to implement in her present. By analyzing the effects of covid on the transportation of automotive goods, the author will be able to shed light on the strategies employed by the industry to adapt to the circumstances that arose at the time.

1.8 Risk Matrix

The possible risks the author considered for this research are listed below, with their potential degree of severity, the manageability of it and some key solutions for each of them.

Table 2. Risk Matrix (Author 2022)

Risk Source	Risk	Level of Risk *	Manageability of Risk **	Risk Management Need ***	Risk Management Activities
1	There is no information about the general impacts.	1	1	3	Make deep research between testimonies, and empirical answers. Not only theoretical information
2	Not finding enough field research	1	2	1	Offer rewards in exchange of the survey being taken
3	No big impacts found in the supply chain.	2	1	2	Take the hypothesis, and explain the findings even if they are not what the author expected
4	Not finding information in the field research	2	1	3	Base the thesis in pure theory and testimonies found in already done surveys or interviews

* **1 High:** Must be managed to keep the project viable, **2 Intermediate:** Should be managed, **3 Low** Unlikely to arise; does not need to be managed

** **1 Manageable by researcher, 2 Manageable by partner or another accessible party, 3 Not manageable** by 1 or 2 → Abandon project.

*** **1** High priority, **2** Medium priority, **3** Low priority

All the factors mentioned can affect the research subject in different ways and with different severity. It is important not to take any element for granted or underestimate it. The ranking of these factors is based on priority to address and ease of management.

1.9 Key Concepts

Logistics: It is a process in which the planning, the implementation and the controlling of the goods aims to be efficient. Logistics also include activities such as transportation, the storage, packaging, inventories, and distribution of products. The main goal is to make this process with the minimal costs and resources.

Transportation: It is the movement of products from one point to another. It plays a very important role in the exchange of good between two parties. In the automotive industry, the transportation can include the movement from raw material to finished goods in the supply chain.

Supply Chain: A supply chain is the network of all the individuals, organizations, resources, activities, and technology involved in the creation and sale of a product. A supply chain encompasses everything from the delivery of source materials from the supplier to the manufacturer through to its eventual delivery to the end user. The supply chain segment involved with getting the finished product from the manufacturer to the consumer is known as the distribution channel. (Lutkevich, B. 2023)

Coronavirus disease (COVID-19): an infectious disease caused by the SARS-CoV-2 virus. Most people infected with the virus will experience mild to moderate respiratory illness and recover without requiring special treatment. However, some will become seriously ill and require medical attention. Older people and those with underlying medical conditions like cardiovascular disease, diabetes, chronic respiratory disease, or cancer are more likely to develop serious illness. Anyone can get sick with COVID-19 and become seriously ill or die at any age. (World Health Organization, 2023)

Adaptation Strategies: Actions taken by automotive companies to adjust their operations and supply chain processes in response to transportation disruptions caused by the external causes. These strategies are there to reduce risks, increase the resilience, and maintain operational continuity.

Automotive industry: all those companies and activities involved in the manufacture of motor vehicles, including most components, such as engines and bodies, but excluding tires, batteries, and fuel. The industry's principal products are passenger automobiles and light trucks, including pickups, vans, and sport utility vehicles. Commercial vehicles (i.e., delivery trucks and large transport trucks, often called semis), though important to the industry, are secondary. (Britannica, 2023).

Technology Integration: Incorporating advanced technological solutions, such as automation, digital tools, artificial intelligence, and data analytics, into the transportation and logistics operations of the automotive supply chain. This integration is needed to improve efficiency of the transportation.

2 Transportation element of the supply chain of automotive industries

This section will be establishing what the thesis will be focusing in. The theoretical framework of this paper will bring to the author and the lecturer a general idea of what the aforementioned will be covering. The report will include concepts that can open the topic to several point of views and observations on the more specific area of the thesis.

This theoretical framework will have as base a wide variety of concepts that are important for the development of the paper. Therefore, the main topics will have to cover from general to specific.

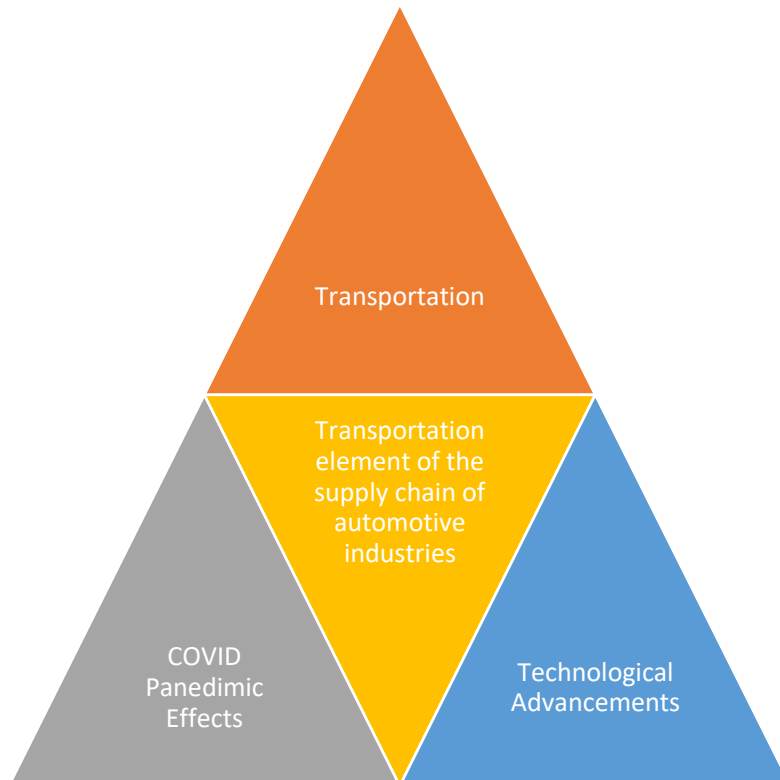


Figure 1 Theoretical Framework (Author 2023)

2.1 Transportation

Transportation plays a fundamental role in the supply chain, as it establishes the connection between two parties that are in search of supply and demand. The transportation of goods also plays a crucial role in the automotive industry, as it is one of the most efficient methods to reduce costs and use as few resources as possible. Its management can be affected if its visibility is not complete since the transportation of goods has its own supply chain.

This means of transportation refers, as mentioned above, to the movement of material from one point to another, which may travel through several points to reach its final customer. In order to achieve an efficient transportation supply chain, it is necessary to be able to visualize it completely,

including logistics. According to the article "The transportation in the supply chain" by Supply Chain Dive, in the United States, the percentage that represents the cost of transportation of goods amounts to 6% of GDP, representing that a large part of the costs come from transportation.

Reiterating the importance of the role of transportation in a supply chain, we can explain that an automobile is manufactured with various components from different parts of the world. As we know, Mexico is one of the countries with the largest automotive industry in the world. Odracir Barquera, General Director of the Mexican Automotive Industry Association (AMIA for its acronym in Spanish), stated that "Among the main producing countries in the world during 2022, China is the first place with 27 million units, the United States the second with 10 million, followed by Japan, India, Korea and Germany. Mexico remains in seventh place". This association also shares statistical data that, from January 2022 to February 2023, 3,334,260 light vehicle units were exported, with the United States receiving 77.4% (2,581,969 units). The remaining 22.6% was distributed among countries that include Canada, Germany, Puerto Rico, Colombia, Brazil, Chile, United Kingdom, Japan, and Australia.

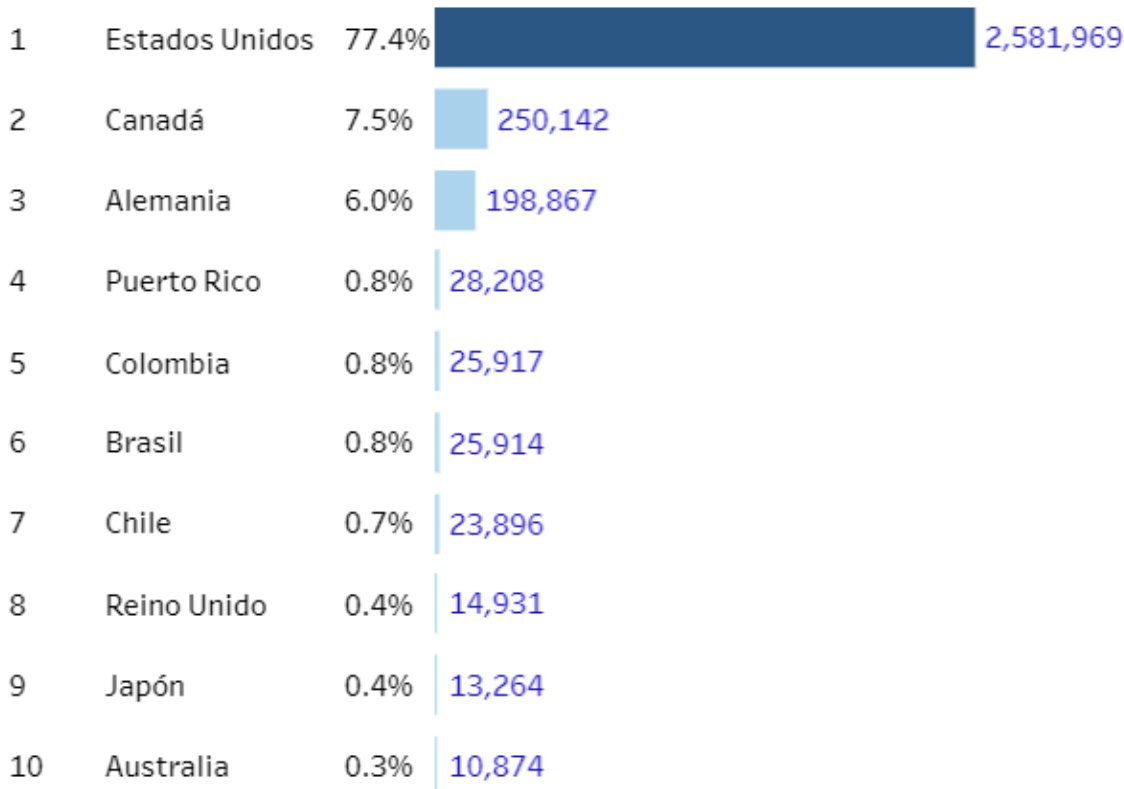


Figure 2 AMIA. Exportation of Light Vehicles, 2023. (<https://amia.com.mx/exportacion-de-vehiculos-ligeros1/>)

Each of the components has its own supply chain and several suppliers in turn. It is for this very reason that a good that needs to be manufactured may include levels such as the manufacturer,

which acquires materials from the supplier at level 1, which in turn acquires goods from companies at level 2, and so on. This is where transportation plays the key role as the link between all the levels, making them work as a coherent whole between materials, parts, products, goods, etc., arriving at the end point at the perfect time for use. The strategic management of these movements is called Logistics. Logistic operations can be carried out by the carrier itself, in this case by land. However, there are also companies that perform the logistics service, subcontracting units that can perform the movements. Managers of logistics companies must ensure that the strategies being employed in the means of transportation, is adequate to their competitive support. Companies are tasked with evaluating the function to be performed, based on the combination of cost, inventory, and capacity to successfully obtain the most strategic result.

2.1.1 The Impacts of not Understanding the role of Transportation in the Supply Chain

If the strategies employed by a logistics service fail to reduce high costs, several factors can play a role, such as unnecessary expenses that could have been avoided, which reduce the overall profit margin. A loss of product can also occur when a part number, piece, or component is overstocked, because warehousing costs are also affected. Lack of control in raw material pricing can also be an area of opportunity that is directly affected by where it is located, and the transportation cost it may require. If there is a raw material that has a lower cost in a foreign country, such as Mexico, but the transportation of the raw material is inefficient, it can escalate to the point where it may be a better option to source the raw material from the manufacturer or manufacturer's location. This is especially true for large companies where the supply chain visibility of the transportation itself is clear, becoming a crucial element for their profitability.

2.1.2 The Balance of Transportation Supply Chain

Usually, the management of a supply chain becomes a balancing act between service and cost. This is most notable in the transportation element. There will always be countless and variable ways of transporting goods from one place to another, but if foreseen, these different ways will be balanced against the cost. In order to make this balance, precise planning is needed in advance to ensure that the materials will arrive on time, and thus reduce the cost of transportation and even storage.

We can see the supply chain as a living thing that is constantly changing. There are suppliers who want to challenge themselves to be presented as the best price or service, even though raw materials may fluctuate. These changes to services or goods can directly affect the transportation

supply chain, meaning that the chain is not static, and is prone to change making it dependent on planning needs. Consequently, transportation systems must change in response to these changes, and the shipper is responsible for managing the changes necessary to achieve the objective.

Most of the problems in the transportation supply chain are easily solved thanks to the transportation management systems that exist today. These systems provide analysis to address the need for smarter business decision making, becoming more vulnerable as demand increases and the operation grows to a larger scale.

2.2 COVID Pandemic Effects

77.7% of the vehicles used worldwide come from 10 countries that are the main producers: China, the United States, Japan, Germany, India, Mexico, South Korea, Brazil, Spain and France. However, given the contingency caused by COVID 19, the automotive industry was affected like a domino effect, due to the dependence among these 10 countries. According to the Argentine-German Chamber of Industry and Commerce, 80 percent of the industry's supply chain is directly connected to China, so the closure of the Chinese auto parts market (located in Wuhan) completely disrupted the industry. This became even more of a problem when the Chinese epidemic was declared a global pandemic. As a result, companies were forced to suspend partially or even completely, many of their industrial complexes in order to comply with the new sanitary rules that would be imposed.

In Mexico, the situation did not change. Due to the shortage of many auto parts, the different assemblers in Mexico had to suspend their activities since March 23, 2020, where, at that time, approximately 320 people were infected and 2 died nationwide by COVID 19.

Suspending this industry would have enormous consequences due to two aspects; the first is that this sector had manufacturing and maquiladora plants in 11 cities in Mexico: Aguascalientes, Puebla, Guanajuato, Nuevo Leon, San Luis Potosi, Sonora, State of Mexico, Jalisco, Morelos, Coahuila and Baja California. In Mexico, before the pandemic, the National Institute of Statistics, Geography and Informatics (INEGI) confirmed that around 24 plants employ more than 965,000 workers, where 800,000 are dedicated to the manufacture of auto parts, being one of the main generators of employment in Mexico. The second is that, being one of the sectors with the highest production, putting the health of the employees of this industry at risk was not an option. Nevertheless, the reactivation of the industry was extended until June 1, 2020, 10 weeks later than previously planned, when the authorities finally declared it as an essential activity. This extra period of

confinement was extended as Mexico registered more than 112,000 new infections and more than 15,000 deaths from coronavirus in early April and late May of the same year.

Finally, the main companies with the largest presence (Nissan, Volkswagen, General Motors, Kia, Toyota, and Honda) that concentrate 74% of the light vehicle market in Mexico, took measures that restricted their operations to a great extent, however, they were taken in order to be able to finally return to their activities. Consequently, during the months of March and May, the industry was already showing negative numbers. INEGI reported in 2020, that Mexican car production at national level fell 91.5%, when at its lowest point (April 2020), only 3,722 units were reported. While sales dropped 60% in that same period, increasing 20% in May.

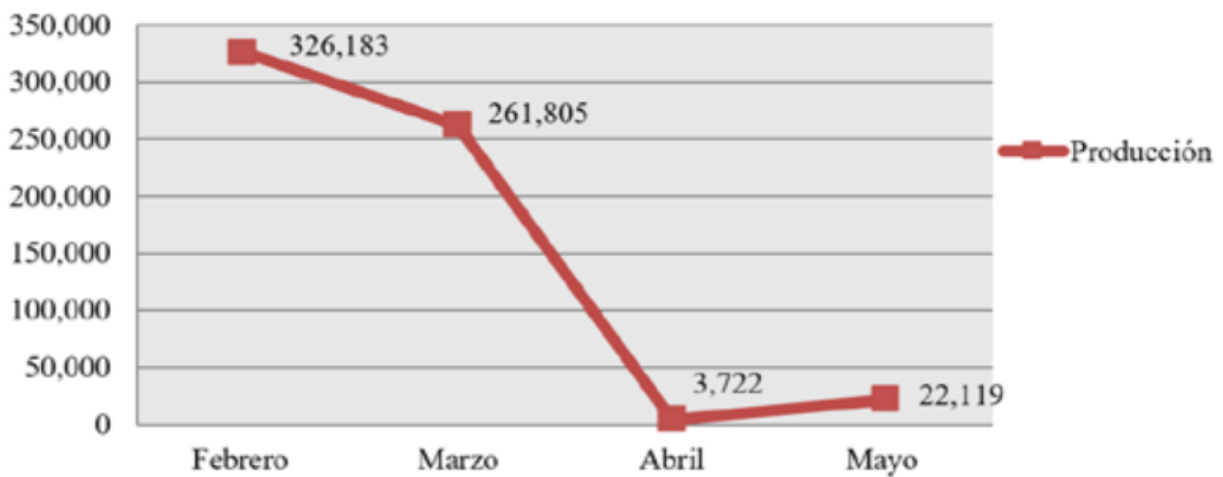


Figure 3 Aguilar, F. The Covid-19 Pandemic and Its Impact on The Mexican Automotive Industry, 2020. (<https://espacioimasd.unach.mx/index.php/Inicio/article/view/240/788>)

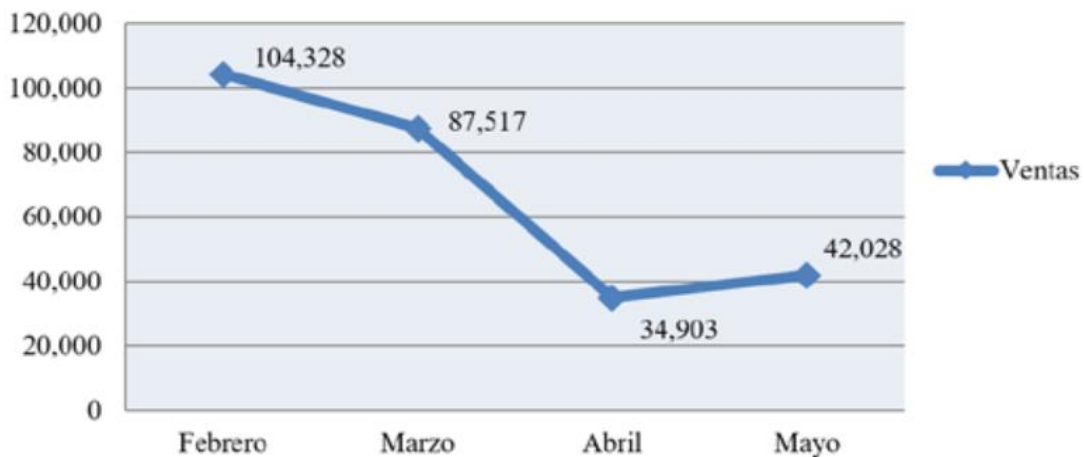


Figure 4 Aguilar, F. The Covid-19 Pandemic and Its Impact on The Mexican Automotive Industry, 2020. (<https://espacioimasd.unach.mx/index.php/Inicio/article/view/240/788>)

2.3 Technological advancements in the automotive industry since COVID

2.3.1 Robots colaborativos

After the pandemic, the industry had to make many changes; with the reduction of personnel, they had to innovate and adapt to be able to continue and not stop the production line. The application of robotics in logistics and product transportation advanced drastically in the last few years post pandemic. The change it brought to the industry was very big with many positive consequences. Robotics was applied to the automation of tasks such as the organization of shipments and deliveries. "The difference between traditional machinery and industrial robots is that these are associated with artificial intelligence systems that allow them to handle more complex variables and react quickly and independently through algorithms" (Borras, I. 2020). This refers to the fact that unlike a robotic arm of a conventional chain, a robot with logistic intelligence is able to learn new tasks and execute in the same way those that needed human assistance. Unlike industrial robots, these serve as support for manual work and to streamline processes, but do not have progress itself.

2.3.2 Types of robots

Automated arms and machinery

Automated arms and machinery are robots that can pick products, close and seal boxes, or even move packages from one shelf to another. This type of machinery is the most used so far and many companies already have this type of technology, but more in the automotive sector. The difference from the more conventional machinery robots is that this type of robots can perform more complex activities such as analyzing and supporting operators during repetitive activities or even when it is a more complex physical labor. It can also manage and place pallets for the closing of transport boxes.

Drones

Drones are undoubtedly the most well-known management systems that often come to mind when talking about artificial intelligence. A drone is a robot that can transport units to places that are difficult to access, such as high shelves or small places. There are different types, but they started to be used because of the lack of personnel that the pandemic demanded.

This is an example of a drone from the company "On.Drone".

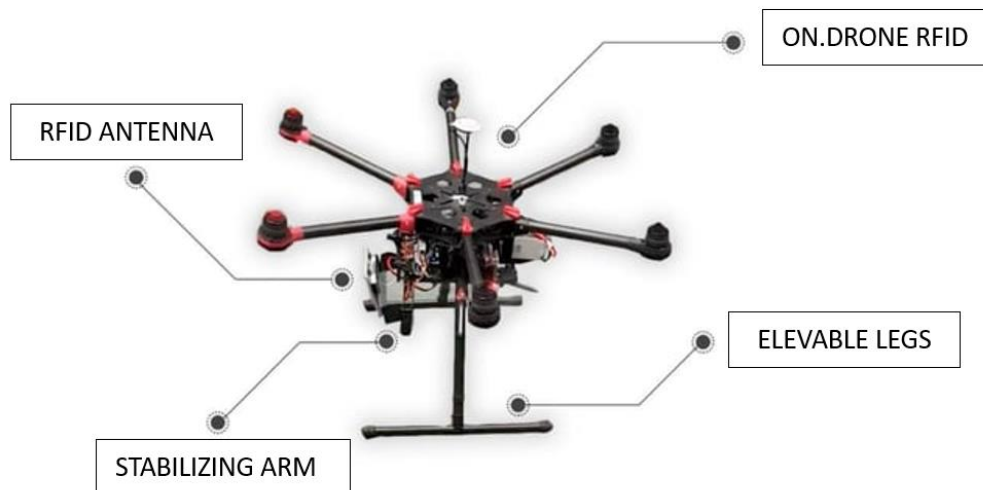


Figure 5 Borrás, I. Robotics in logistics: how it is changing product distribution, 2020. (<https://blog.saleslayer.com/es/robotica-logistica#que>)

2.3.3 Exoskeletons

They are mainly used to improve the functionality of the workstations and reduce the leisures that could occur on the conveyor line. This technology ensures the well-being of the workers and allows to achieve greater efficiency in the times and activities of each loading and unloading.

2.3.4 QR code

The QR code, as we already know, had its boom during the pandemic, since it digitized many processes that should have been physical, and thus avoided contact and with it, the contagion of COVID 19. It began to be used for the training of truck operators, as it could contain infinite information, and even to be able to review data on loads without the usual contact.

2.3.5 Transportation driven by technologically advanced integrated systems.

Many companies manage to identify the transportation supply chain as a core activity, but it is often used as an anchor to attract investors. However, this happens because many companies do not find the right ways to implement transportation and supply chain visibility. One of the main reasons why this is not happening is because it requires true systems integration that operates across many of the elements of the supply chain. The harmony of this process is complicated, but not impossible to achieve. Different tools, such as warehouse management, ordering systems, planning systems, ERP, and transportation management systems, are needed to achieve it. When all these tools are well distributed, what holds them together is that they all have the goal of getting the materials from the starting point to the destination point. For this harmony that has been mentioned,

technologies must be used, and invest in them. The consequences can be serious if a company does not learn to use them, such as creating idle labor, lost sales, delays, unnecessary expenses; and here is the importance of transportation. Other technological advances promise that this integration will also be physical. One example is the robotic devices mentioned above, which connect trailers, pallets, and container systems in transportation. But of course, proper implementation is necessary for them to be successful.

3 Research Methods

The selected research method is quantitative research. The tool will be a questionnaire aimed at the population that was working in the transportation area of the automotive industry during the pandemic. The questionnaire will be provided to respondents from Mexico and the USA.

In the research study, the questionnaire will include the quantitative method. This will involve the interviewee giving a value of importance to the aspects connected to the chosen topics. Additionally, the questionnaire will feature open-ended questions where the recruiter will share their opinion based on their experience and background, related to the study case.

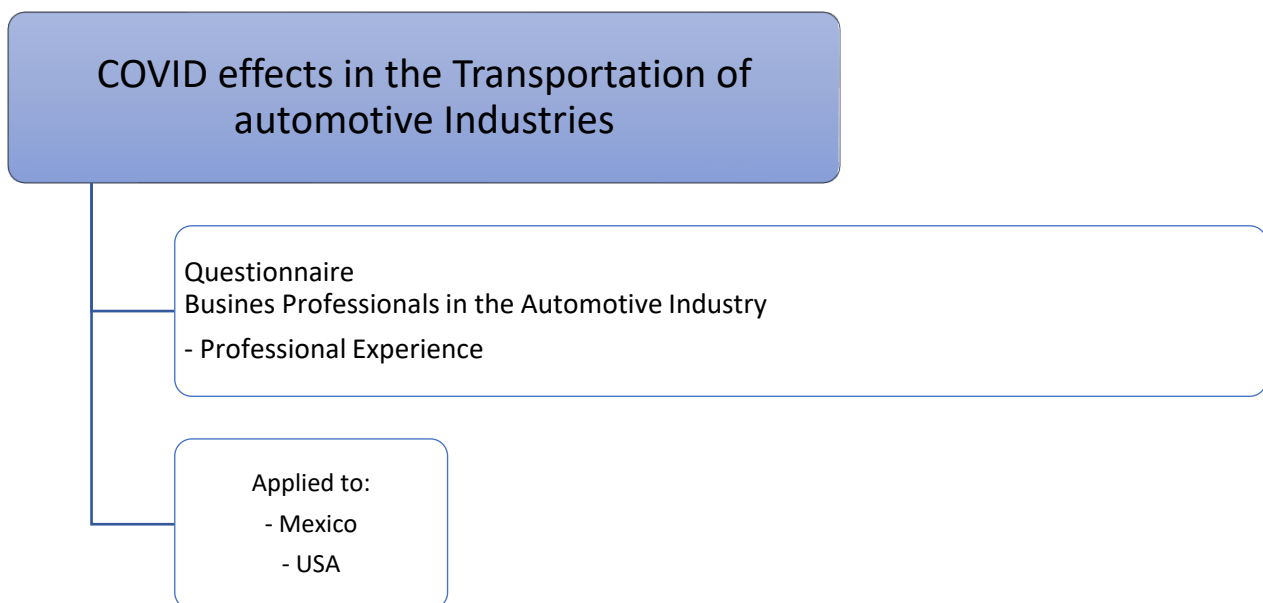


Figure 6 Mapping structure (Author 2022)

3.1 Population and Sample

The author aims to collect the information from field research, interviewing 40 professionals that have been for over 4 years in the automotive industry, specifically the transportation and logistics area. The survey respondents are intended to be both Mexican and American, as the author has the background and context in the Mexican industry and the American. This will serve as a point of comparison between what Mexican industries experienced, and what American industries experienced. The targeted group will be mostly supplier for car brands.

The range of industries and time of experienced were chosen based were chosen based on what the paper is being written about. The 4 years of experience will be necessary since the pandemic started 4 years ago, so survey respondents need to have been in the field at least since the pandemic began. The demographics of the study are the ones chosen based on what the paper is being focused on, a study case from Mexico and the US.

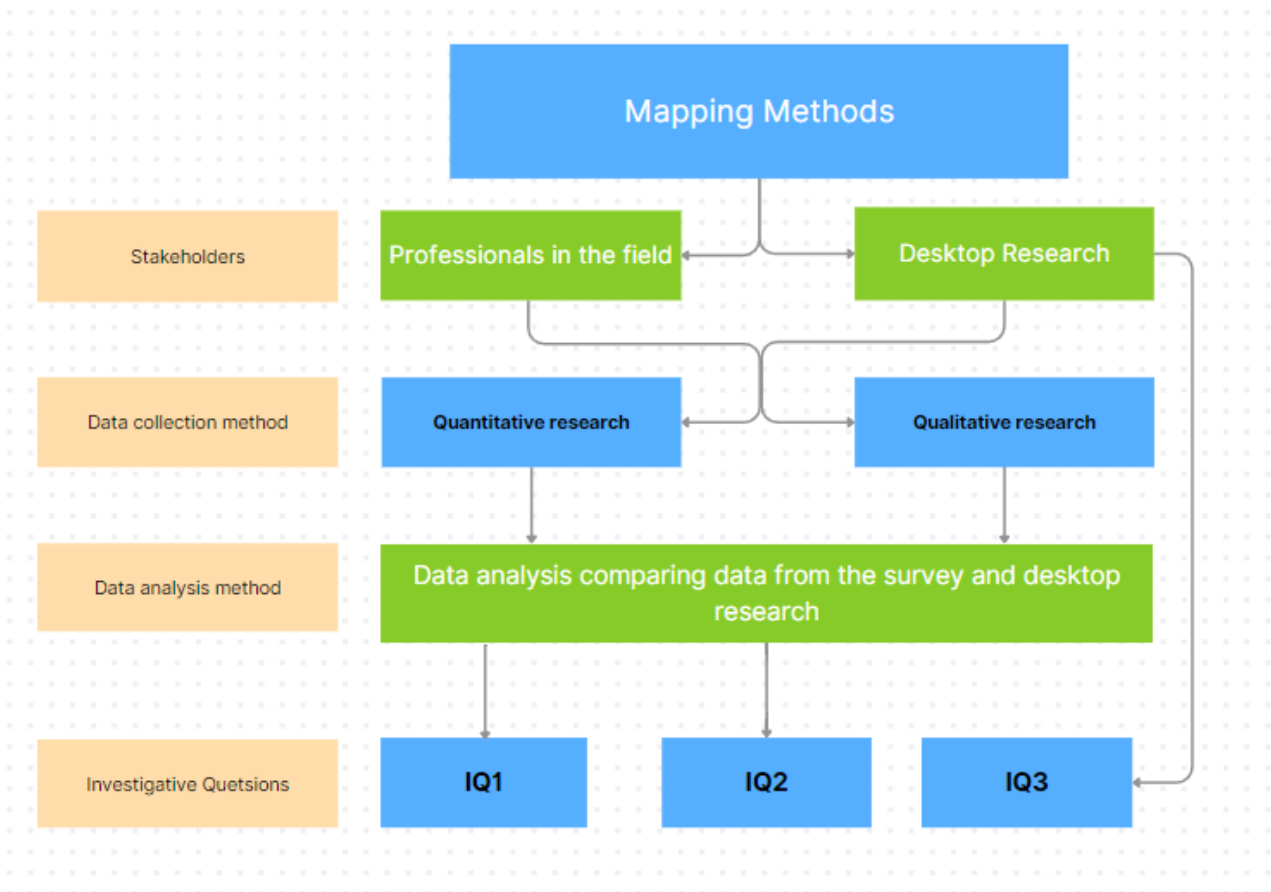


Figure 7 Research Methods Design chart (Author 2023)

3.2 Description of implementation

It is expected from this survey, to understand how the industry managed to cope with the COVID 19 pandemic, since transportation, being a key element in the supply chain, was merely affected by the phenomenon. Afterwards, the information will be collected to be analyzed in order to arrive at the results of the investigative questions. This same information will be complemented with desktop research. As mentioned at the beginning, there was a risk that the information in the field research would not be sufficient for comparison. However, precautions were taken to be able to

collect as many responses as possible, since the author is part of the population sector of interest, thus sharing the survey with his collaborators.

Table 3. Survey for Professionals. (Author 2023)

Investigative Question (IQs)	Theoretical Framework	Survey Questions
IQ1. What is the role of transportation in the supply chain of an automotive industry?	2.1, 2.1.1, 2.1.2	2, 3, 4, 6, 7, 8, 9, 10, 11
IQ2. How big was the impact due to the breakdown in the transportation of the supply chain?	2.2	3, 4, 6, 7, 9, 12.
IQ3. What are the technological advancements in the transportation since COVID?	2.3, 2.3.1, 2.3.2, 2.3.4, 2.3.5	8, 10, 12.

To whom it may concern,

As we navigate through unprecedented times, the automotive industry has encountered various challenges stemming from the global COVID-19 pandemic. This survey aims to gather insights into the profound effects of this crisis on transportation logistics within the automotive sector. Your valuable input will enable us to better understand the nuanced impacts, disruptions, and adaptations that have occurred within transportation networks, supply chains, and logistical operations due to the ongoing pandemic. Please access on the following link: <https://link.webpolsurveys.com/S/AC78F7956855F931>

Your candid responses will assist in evaluating the magnitude of changes faced by the industry, allowing us to identify key areas for improvement, resilience-building strategies, and potential avenues for future preparedness.

Thank you for taking the time to participate in this survey. Your input is invaluable in shaping the future of the automotive industry's transportation landscape.

Sincerely,

Paola Montserrat Olin Delgado.

4 Results

The global COVID-19 pandemic has set challenges across industries, with the automotive sector being deeply impacted. Among the numerous elements on the supply chain of this industry, the transportation of automotive goods, faced important disruptions, prompting a reevaluation of logistical strategies and operations. This paper presents the findings from the survey titled "COVID Effects in the Transportation of Automotive Industries," aiming to delineate the repercussions of the pandemic on transportation networks within the automotive sector.

In the middle of the pandemic's beginning, transportation within the automotive industry encountered a ton of obstacles, ranging from supply chain interruptions to logistical challenges. The survey, conducted across a diverse spectrum of automotive stakeholders, sought to capture the nuanced impacts experienced by transportation logistics due to COVID-19. Through a quantitative approach, the survey delved into various facets of this critical industry segment, seeking to assess the severity of disruptions, adaptations made in response to challenges, and the efficacy of implemented strategies to mitigate the pandemic's adverse effects.

The survey incorporated a wide-ranging set of questions in aspects such as transportation delays, cost variations, international supply chain interruptions, workforce impacts, and technological adaptations made to cope with the circumstances imposed by the pandemic.

4.1 Results of business professionals surveyed.

The first question was asked to exclude those professionals who were not present during the pandemic, as we can see that the author intends to collect information only from this period. Since the pandemic is now approximately 3 years old, it was necessary to segregate the population segment to be surveyed.

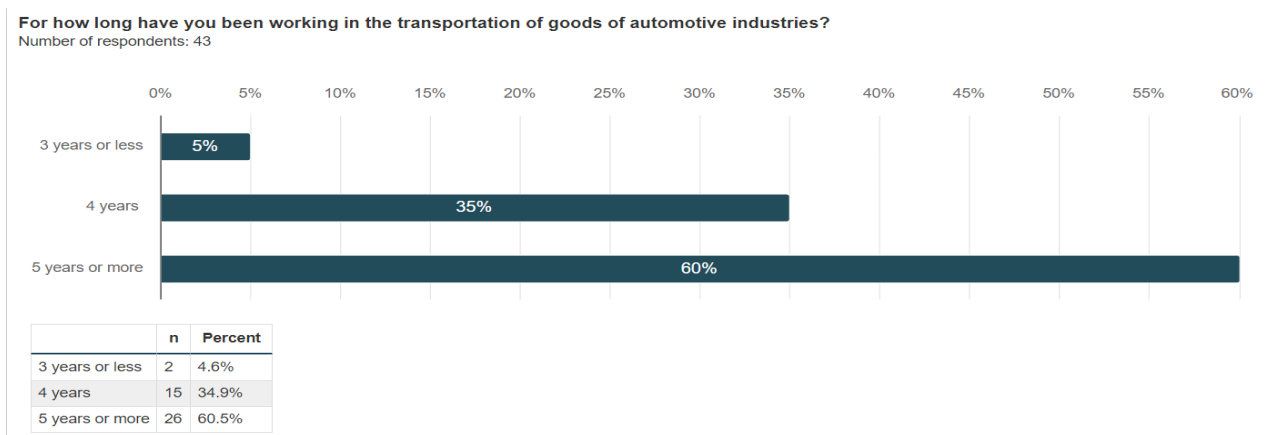


Figure 8 Question number 1, Business professionals survey (Author 2023)

Figure 8 shows that 35% of the respondents had been working in this segment for an average of 4 years. Most of them, with 60%, had more than 6 years working in the transportation area. This was the beginning of the survey.

The next question will focus on what overall impact respondents observed during the pandemic directly on the logistics of transportation of auto parts and materials.

See Figure 9.

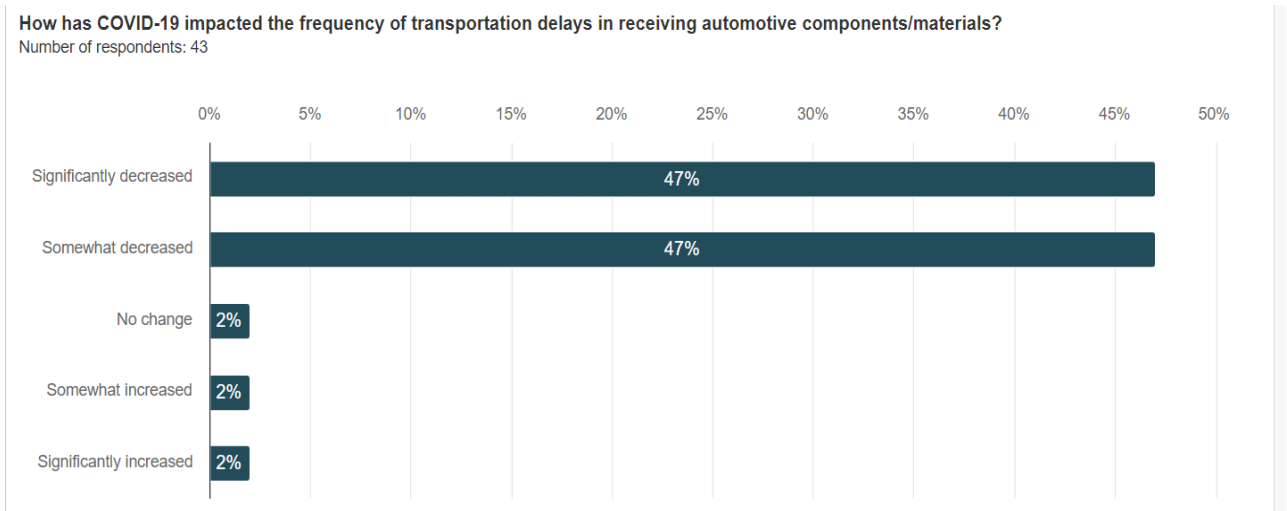
On a scale of 1 to 10, how significantly has COVID-19 affected your company's transportation logistics for automotive parts and materials?
Number of respondents: 43

Min value	Max value	Average	Median	Sum	Standard Deviation
1.0	10.0	6.8	7.0	292.0	1.2

Figure 9 Question number 2, Business professionals survey (Author 2023)

On the scale of 1 to 10, it can be seen that the highest response (median) was 7, while the average response was 6.8. This shows that more than half of the respondents, from different automotive companies, confirmed that they had direct repercussions on their supply chain, more specifically on the logistics of their transport service.

For question 3, the author focused on learning what delays in the receipt of materials, based on their transportation, occurred during the containment period.



	n	Percent
Significantly decreased	20	46.5%
Somewhat decreased	20	46.5%
No change	1	2.4%
Somewhat increased	1	2.3%
Significantly increased	1	2.3%

Figure 10 Question number 3, Business professionals survey (Author 2023)

In this figure it can be clearly seen how 93% of the answers are divided between "significantly decreased" and "Somewhat decreased". Analyzing, it can be concluded that as in a supply chain, the "whiplash" effect began to appear from the beginning of the pandemic. As it is well known, a supply chain works when there is a correct coordination of all its elements, and 94% of the respondents presented a backlog of materials as a consequence of the delay or lack of means of transportation for their auto parts.

For question number four, respondents were asked how they could state the percentage between the cost variation for the transportation of their materials. See figure 11.

What percentage increase/decrease did you experience in transportation costs during the COVID-19 pandemic for automotive logistics?
 Number of respondents: 42

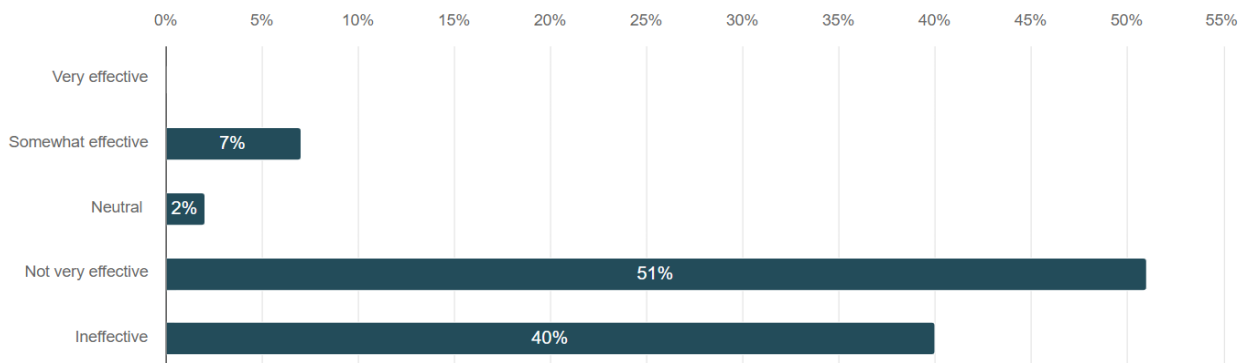
Min value	Max value	Average	Median	Sum	Standard Deviation
20.0	85.0	64.6	70.0	2715.0	16.0

Figure 11 Question number 4, Business professionals survey (Author 2023)

In this case, respondents answered with an average of 64%, with 0% representing no changes, and 100% representing drastic and complete changes, this figure represents that more than the majority of their transportation costs had variations, thus affecting a smooth supply chain. As already mentioned, if one of the most important parts of logistics, such as transportation, varies its costs, especially in increase, it will create a domino effect causing the costs of the final product to increase (as was seen during and after the pandemic).

Question 5 focused on understanding whether alternative transportation had been used, as well as its efficiency. The purpose of this was to review the results of using alternative transportation in order to avoid delays, backlogs or delays in the chain.

Rate the effectiveness of alternative transportation methods (if any) adopted during COVID-19 for automotive logistics:
 Number of respondents: 43



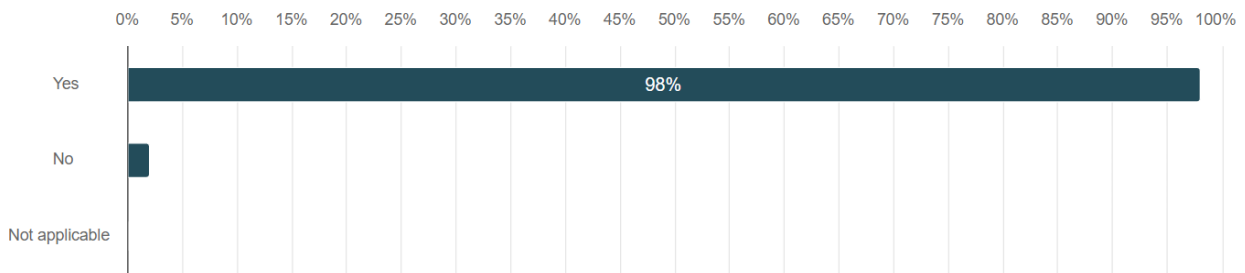
	n	Percent
Very effective	0	0.0%
Somewhat effective	3	7.0%
Neutral	1	2.3%
Not very effective	22	51.2%
Ineffective	17	39.5%

Figure 12 Question number 5, Business professionals survey (Author 2023)

The result obtained was that 52.2% found that using alternatives was not efficient because, if we return to the importance of transportation in the supply chain, resorting to external transportation directly affected costs due to the scarcity of adequate means of transportation.

In this section, the interviewees were asked about the difficulties they encountered in the supply of auto parts for their production. Mexico, being one of the countries with more auto parts maquiladoras in the world, experienced a shortage of parts brought from abroad, in this case from the United States, after the closing of borders and the restrictions for the sector, being awarded to a non-primary activity by the Mexican government until June 2020.

Have there been interruptions or difficulties in obtaining international automotive parts due to COVID-19-related transportation restrictions?
Number of respondents: 43



	n	Percent
Yes	42	97.7%
No	1	2.3%
Not applicable	0	0.0%

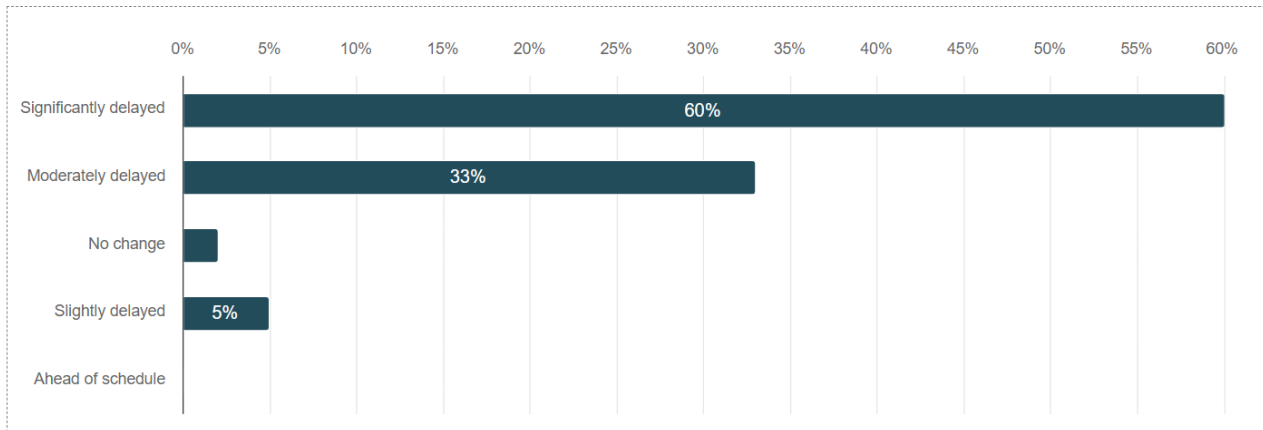
Figure 13 Question number 6, Business professionals survey (Author 2023)

We can see that 97.7% of the respondents stated that the auto parts that were imported into the country, presented delays or difficulties to be entered, being that the pandemic and the confinement affected their suppliers in the same way as the Mexican industry.

The reason for the question: "How have transportation challenges during the pandemic impacted your overall production timeline for automotive products?", is directly related to question number 6, since the industry, lacking both goods and ways of transportation, was severely affected in production lines.

How have transportation challenges during the pandemic impacted your overall production timeline for automotive products?

Number of respondents: 43



	n	Percent
Significantly delayed	26	60.5%
Moderately delayed	14	32.6%
No change	1	2.3%
Slightly delayed	2	4.6%
Ahead of schedule	0	0.0%

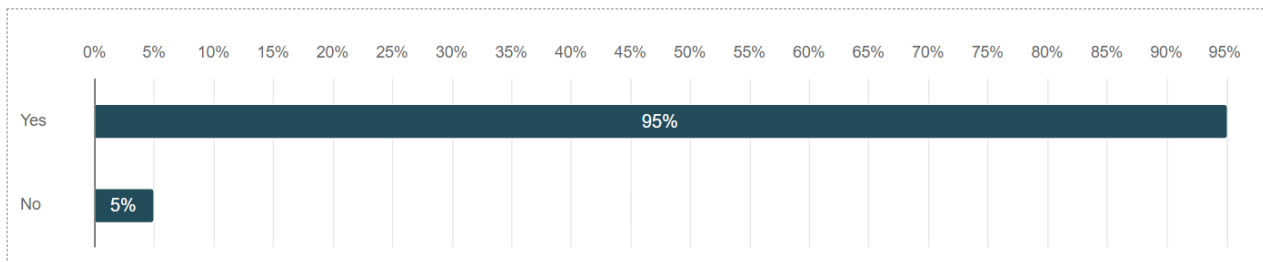
Figure 14 Question number 7, Business professionals survey (Author 2023)

We can observe a 93.1% positive response to the lags presented during the pandemic.

In order to learn more about how one of the most sensitive industries in terms of supply chain, employees were asked if the company they work for implemented new technologies or strategies to be able to mitigate the disruptions during the COVID 19 period.

Has your company implemented any new technology or strategies to mitigate transportation disruptions during the COVID-19 period?

Number of respondents: 41



	n	Percent
Yes	39	95.1%
No	2	4.9%

Figure 15 Question number 8, Business professionals survey (Author 2023)

The answers are clear. The automotive sector plays a very important role worldwide, for countries that are world powers, such as Mexico, it is very important to keep up to date, to be able to face any challenge and be prepared for even the most unexpected risks. It was to be expected that 95.1% of those surveyed stated that the company was able to adapt to the situation with the help of new technologies and strategies. The companies in the sector, year after year, carry out

trainings, conventions, etc., to be able to keep up to date with their competitors, so it was not expected less from a situation like COVID-19.

Continuing with initiatives or support from other parties, the interviewees were asked if they would have benefited from actions taken by their government to address this phenomenon.

Please rate the effectiveness from 0 to 10, of government support or initiatives in mitigating transportation challenges for the automotive industry during COVID-19

Number of respondents: 43

Min value	Max value	Average	Median	Sum	Standard Deviation
1.0	8.0	3.0	2.0	128.0	1.8

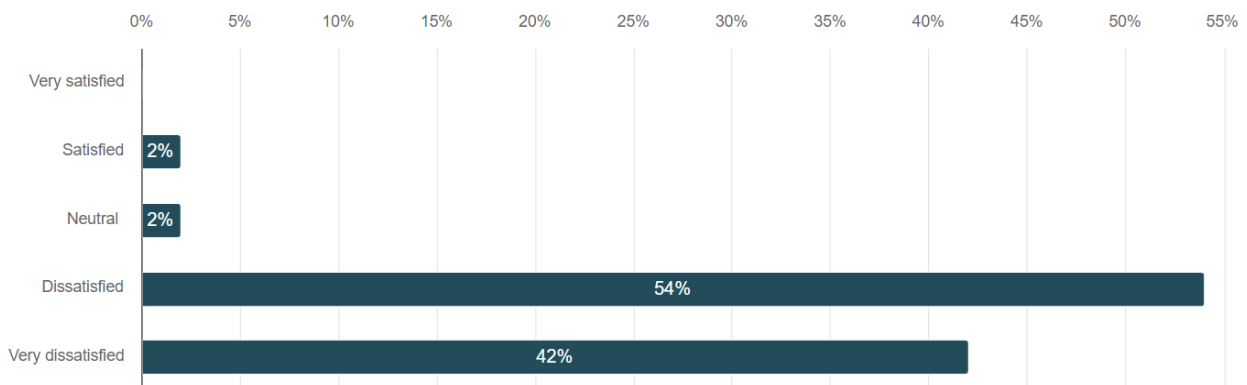
Figure 16 Question number 9, Business professionals survey (Author 2023)

As the research had confirmed, the Mexican government did not take measures in favor of this industry, as it would have classified the sector as a "non-primary" activity, affecting production, transportation, the entry of materials into the country, exports, maquila and the jobs of thousands of Mexicans. The average of this survey is proof that there was no such support and initiatives from the government, with an average of 3 out of 10, and an average of 2 out of 10.

For question number 10, the question was focused merely on the communication of the supply chain stakeholders in the transportation element. The purpose of this question was to find out if this factor could be a determining factor for the disruption of the supply chain in transportation.

How satisfied are you with the communication and coordination between transportation partners (shipping companies, carriers, etc.) during the pandemic?

Number of respondents: 43



	n	Percent
Very satisfied	0	0.0%
Satisfied	1	2.3%
Neutral	1	2.3%
Dissatisfied	23	53.5%
Very dissatisfied	18	41.9%

Figure 17 Question number 10, Business professionals survey (Author 2023)

As can it be seen, for 95.4% of the respondents, there was a lack of communication among all stakeholders, and this may be one reason why, when faced with the crisis, the transportation element was disrupted.

The next part is related to the last question, as it asks respondents whether they found a reliable service from them, including all fields related to transportation and logistics (carriers, logistics companies, etc.).

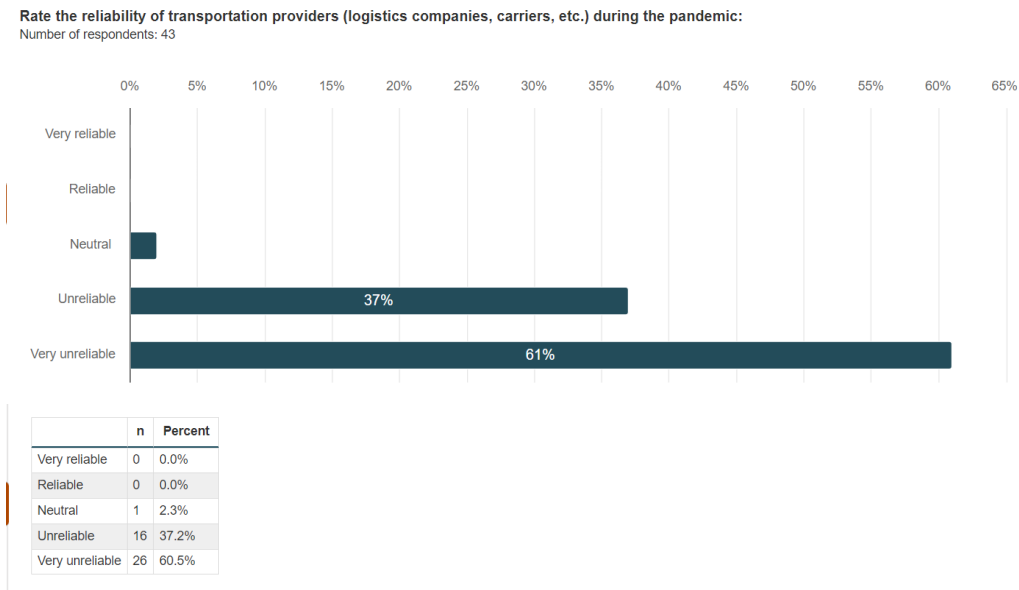


Figure 18 Question number 11, Business professionals survey (Author 2023)

The results were negative to the reliability they had, as according to the research, the picture changed in terms of cost and service during the pandemic.

For the last question, the author focused on open-ended questions about what proposals would have been made to combat the consequences that were occurring at that time.

In hindsight, what changes or improvements would you propose to better manage transportation issues during similar crises in the future?
Number of respondents: 40

Responses
Make sure that every driver abides by the new Covid-19 vaccine and guidelines
Coordinate similar plans of action with others managers.

Invest in infrastructure technology
Prioritize essential services
Enhance communication channels
Be more flexible in transportation options
Propose better regulations, and in the future for the government to establish our industry as primary
Contribute to more collaborative planning and coordination.
Invest in technology.
Enhanced emergency response
Sustain transportation options
Increase accessibility.
Utilize data and analytics.
Strengthen infrastructure resilience.
Incorporate smart technology
Promote alternative changes to transportation.
Engage with the community
Strengthen public-private partnerships
To do continuous learning and adaptation.
Implementing dynamic traffic control measures to adapt to changing conditions.
Investing in alternative fuel
Create more designated pick-up and drop-off zones.
Implement flexible work hours.
Develop contingency plans
Strengthen coordination between transportation providers.
Implementing congestion pricing strategies
Enhancing the resilience of transportation infrastructure.
Expanding the use of real time navigation apps.
Integrating transportation management systems.
Improving the accessibility of transportation options
Investing in research and development.
Establishing dedicated communication channels.

To get better communication
Prioritize the development of alternative transportation
Implement flexible work policies
Implementing dynamic pricing
Enhancing the use of technology for real time traffic.
Investing in research and development to explore innovative transportation solutions.
A fully scalable System is needed so that the supply chain be totally transparent, reliable, and effective

Figure 19 Question number 12, Business professionals survey (Author 2023)

The results obtained from the respondents highlight among them the need for companies to adhere to protocols and for employees to keep up to date with their vaccinations in order to maintain a safer operating environment. The proposal to maintain a lot of communication between stakeholders is also repeatedly mentioned.

5 Conclusions

The final chapter of this paper will focus on revealing the most important results found between the theoretical data and the field research. Both parts played a very important role in the search for results for the questions that the author generated at the beginning. This part also aims to provide a less specific, more general overview of the impact of COVID on the transportation element of the automotive supply chain. Always with the objective of contributing to future situations that place this sector in a critical state and to be able to have a more profound reaction.

5.1 Discussion

IQ1. What is the role of transportation in the supply chain of an automotive industry?

Transportation plays a critical role in the automotive sector of the supply chain. It is a vital link that facilitates the movement of goods within the supply chain network. Its role encompasses several crucial functions:

1. *Transportation acts as an intermediary linking supplier, assemblers, and consumers. It ensures the flow of products from their origin to the final destination.
2. *Timely transportation is essential to meet customer demand. Efficient transportation ensures that goods arrive at their destination on time, reducing delivery times.
3. *Transportation has a significant impact on supply chain costs. Optimizing transportation strategies, route planning and mode selection can minimize total costs.
4. *Efficient transportation enables better inventory management by reducing overstocks in the various elements of the supply chain. With efficient transportation, companies can maintain smaller inventories without compromising availability.

Overall, transportation is a crucial element of the supply chain ecosystem, influencing the efficiency, profitability, and overall success of the supply chain as a whole. Optimizing transportation strategies is essential to ensure smooth operations and competitive advantage in today's business environment.

IQ2. How big was the impact due to the breakdown in the transportation of the supply chain?

The impact on the supply chain and its transportation element was enormous. As we could observe in the surveys, the coordination of different areas encompassing transportation, such as logistics, carriers, and warehouses, is crucial to maintain harmony and low costs within this element. It was concluded that as the different areas were affected by covid, it directly impacted costs,

inventory and logistics. Alternate transports had to be taken to those usually required, and this translated into chain disturbances where they became a domino effect where one thing triggered the next, and so on and so forth until the line stoppage was created. Even plants had to close due to government regulations, which did not consider the sector as a primary activity.

IQ3. What are the technological advancements in the transportation since COVID?

Since the onset of the COVID-19 pandemic, several technological advances and innovations have emerged in the transportation sector to meet the challenges and adapt to the changing landscape.

Some notable advances include:

1. **Contactless technologies:** The pandemic accelerated the adoption of contactless technologies in transportation, such as contactless payment systems, contactless billing in public transportation, and digital ticketing options. These advances minimize physical interactions, promoting safer travel experiences.
2. **Data Analytics and Predictive Modeling:** The use of data analytics and predictive modeling in transportation has expanded. These technologies leverage data to optimize routes, predict demand patterns, and improve supply chain resilience, aiding in better decision-making and resource allocation.
3. **Smart Infrastructure and Traffic Management:** Investments in smart infrastructure and traffic management systems have increased. Integration of IoT sensors, smart traffic lights, and AI-based traffic management helps in reducing congestion, improving traffic flow, and enhancing safety.
4. **Digital Platforms and Mobility Services:** Digital platforms offering shared mobility services, ride-hailing apps, and multi-modal transportation options have evolved to adapt to changing travel patterns and preferences, providing more flexible and on-demand transportation choices.

6 Appreciations

I would like to express my deep gratitude to all the people who have contributed to the completion of this thesis. First, to my parents Gabriel Olin and Yazmin Delgado, whose unconditional support, love, and sacrifice have been the driving force behind every step I have taken in my academic and professional career. Their constant encouragement and understanding have been a fundamental pillar in this path towards achieving my goals.

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Business professionals survey

COVID effects in the Transportation of automotive Industries



As we navigate through unprecedented times, the automotive industry has encountered various challenges stemming from the global COVID-19 pandemic. This survey aims to gather insights into the profound effects of this crisis on transportation logistics within the automotive sector. Your valuable input will enable us to better understand the nuanced impacts, disruptions, and adaptations that have occurred within transportation networks, supply chains, and logistical operations due to the ongoing pandemic.

Your candid responses will assist in evaluating the magnitude of changes faced by the industry, allowing us to identify key areas for improvement, resilience-building strategies, and potential avenues for future preparedness.

Thank you for taking the time to participate in this survey. Your input is invaluable in shaping the future of the automotive industry's transportation landscape.

1. For how long have you been working in the transportation of goods of automotive industries?

- 3 years or less
- 4 years
- 5 years or more

2. On a scale of 1 to 10, how significantly has COVID-19 affected your company's transportation logistics for automotive parts and materials?



3. How has COVID-19 impacted the frequency of transportation delays in receiving automotive components/materials?

- Significantly increased
- Somewhat increased
- No change
- Somewhat decreased
- Significantly decreased

4. What percentage increase/decrease did you experience in transportation costs during the COVID-19 pandemic for automotive logistics?

5. Rate the effectiveness of alternative transportation methods (if any) adopted during COVID-19 for automotive logistics:

- Very effective
- Somewhat effective
- Neutral
- Not very effective
- Ineffective

6. Have there been interruptions or difficulties in obtaining international automotive parts due to COVID-19-related transportation restrictions?

- Yes
- No
- Not applicable

7. How have transportation challenges during the pandemic impacted your overall production timeline for automotive products?

- Significantly delayed
- Moderately delayed
- No change
- Slightly delayed
- Ahead of schedule

8. Has your company implemented any new technology or strategies to mitigate transportation disruptions during the COVID-19 period?

- Yes
- No

9. Please rate the effectiveness from 0 to 10, of government support or initiatives in mitigating transportation challenges for the automotive industry during COVID-19



10. How satisfied are you with the communication and coordination between transportation partners (shipping companies, carriers, etc.) during the pandemic?

- Very satisfied
- Satisfied
- Neutral
- Dissatisfied
- Very dissatisfied

11. Rate the reliability of transportation providers (logistics companies, carriers, etc.) during the pandemic:

Very reliable

Reliable

Neutral

Unreliable

Very unreliable

12. In hindsight, what changes or improvements would you propose to better manage transportation issues during similar crises in the future?
