M 2023

U.PORTO
FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

# SUPPLIER INCOTERMS CHANGE FROM DAP TO FCA: ASSESSMENT ON PROCESS VIABILITY AND QUALITY IMPROVEMENTS ON AUTOMOTIVE INDUSTRY


## JOÃO PEDRO OLIVEIRA MARQUES

DISSERTAÇÃO DE MESTRADO REALIZADA

NO ÂMBITO DO MESTRADO INTEGRADO EM ENGENHARIA DE MATERIAIS

## MÁRIO AMORIM LOPES

**ORIENTADOR**

PROFESSOR, NO DEPARTAMENTO DE ENGENHARIA E GESTÃO INDUSTRIAL

## VERA VIEGAS

CENTRAL MATERIAL PLANNER PT PLATFORM MANAGER (FORVIA TUTOR)


Porto, 11th of July 2023

| | | | |
|---|---|---|---|
| CANDIDATO | JOÃO PEDRO OLIVEIRA MARQUES | Código | 201605163 |
| TÍTULO | SUPPLIER INCOTERMS CHANGE FROM DAP TO FCA: ASSESSMENT ON PROCESS VIABILITY AND QUALITY IMPROVEMENTS ON AUTOMOTIVE INDUSTRY | | |
| DATA | 11 de julho de 2023 | | |
| LOCAL | Faculdade de Engenharia da Universidade do Porto | | |
| JÚRI | Presidente | | |
| | Arguente | | |
| | Orientador PROF. MÁRIO AMORIM LOPES | | DEGI/FEUP |

# Abstract

The automotive industry is a complex network of interconnected supply chain activities. As part of my master's thesis, I conducted a comprehensive analysis of the industry's supply chain management and explored the potential benefits of incorporating Incoterms, specifically the transition from Delivered at Place (DAP) to Free Carrier (FCA) for suppliers. From all the existing Incoterms to this day (according to the last acknowledgement from the International Chamber of Commerce), DAP and FCA are the most sought ones; this paper studies the impact on our current automotive supply chain regarding incoterm changes from DAP to FCA. Also, it has the goal to assess its process viability in terms of what it takes from both parties to agree to such procedure. This research aimed to optimize processes, enhance quality, and reduce the industry's carbon footprint. For this study, the analysis will be focused on determining how can the proper incoterm be determined while establishing first-hand supplier delivery agreements, as well as to assess how automotive customer's demands can impact the need to possibly proceed to changes in relationship between supplier and Forvia. Secondly, considering the automotive industry's current need to positively impact the environment, we will also decompose how can the proper supplier incoterm help reducing $CO_2$ gases deployment and therefore contribute to a more sustainable environment.

The implementation of the Incoterms changes from DAP to FCA yielded significant positive outcomes in terms of both process efficiency and environmental impact. When it comes to process efficiency, by adopting the FCA Incoterm, we observed a reduction in the total transport flow by 69.5%. This decrease in logistical movements led to streamlined operations and minimized delays, contributing to improved overall productivity. Additionally, there was an impressive 18.18% increase in merchandise shipped. The FCA Incoterm facilitated better coordination between suppliers and manufacturers, enabling a more consistent and timely delivery of goods. Regarding the environmental impact, the study also analyzed the environmental implications of the Incoterms change. The shift from DAP to FCA resulted in a commendable 11% reduction in the global carbon footprint. This reduction can be attributed to the optimized transportation routes and reduced fuel consumption, aligning the automotive industry with sustainable practices.

When it comes to this project's findings, conclusions show that FCA Incoterm was found to have the best choice for the company's supply chain operations. By choosing such an agreement, it is possible to ensure – to all parties included – the visibility, adaptability, and control necessary to improve from a logistic standpoint, while simultaneously reduce the carbon footprint. However, considering that DAP Incoterm can also be suitable in some circumstances, makes us believe the company should assess the possibility for each Incoterm to be analyzed and applied "case-by-case", while carefully considering the advantages and disadvantages of each Incoterm before making a decision.

*I wish to dedicate this Master's thesis to my Mother.*

*Without her sacrifices since day one, as well as for giving me a never-ending motivation to get this stage concluded, this path would have been much more challenging.*

*I am sure that she is proud of me and of who I have become. Hopefully, this can be the cherry on top.*

*Love you, Mother.*

# Index

# List of Figures

# List of Tables

# List of Acronyms

AHP – Analytical Hierarchy Process

ASN – Advanced Shipping Notification

BOM – Bill of Materials

CAD – Computer-aided Design

CAE – Computer-aided Engineering

CAM – Computer-assisted Manufacturing

CAPP – Computer-aided Process Planning

CE – Concurrent Engineering

CIF – Cost, Insurance and Freight

CIP – Carriage and Insurance Paid to

CPT – Carriage Paid to

DAP – Delivered at Place

DDP – Delivered Duty Paid

DPU – Delivered at Place Unloaded

EDI – Electronic Data Interchange

ESD – European Seating Division

ETA – Estimated Time of Arrival

EU – European Union

EXW – Ex Works

FCA – Free Carrier

FOB – Free on Board

ICC – International Chamber of Commerce

JIT – "Just in Time"

JNI – Just Needed Inventory

KPI – Key Performance Indicators

MOQ – Minimum order quantity

OEM – Original Equipment Manufacturers

PC&L – Production Control and Logistics

PDM – Product Data Management

SAP – System Applications and Products

SCM – Supply Chain Management

# 1. Introduction

## 1.1. Automotive industry and supply chain: overview

The automobile industry plays a significant role in global employment, with a complex value chain and connections to both domestic and global economies. The majority of new automobiles are manufactured using advanced processes on moving assembly lines. The automotive industry employs over 2 million people in the EU 27, accounting for approximately 5% of total employment. Globally, car and truck production provides employment for an estimated 8.4 million individuals, with the Asia-Pacific region witnessing notable growth [1].

Intense competition, shifting market demands, and rising customer expectations have made customers more demanding and selective. Market developments, such as shorter product life cycles, increased competition, and demand volatility, have heightened the unpredictability and complexity of demand throughout product life cycles. The automotive industry has faced significant opportunities and challenges in the twenty-first century due to globalization, necessitating improvements in product quality, design, organizational efficiency, and innovation to attract customers and enter new markets. Vehicle manufacturers must be adaptable and responsive to customer needs in order to thrive in this environment [2] [3] [4] [5].

## 1.2. Automotive supply chain business and trade's impact on the environment

In today's global market, companies continue to rely on global sourcing and manufacturing, necessitating collaboration through international trade as a community. Trade agreements encompass aspects of mobility, risk, and financial considerations. The determination of which party, the buyer or seller, assumes responsibility for acts, risks, and expenses in transferring products from seller to buyer is a fundamental aspect of these agreements. Incoterms, which will be extensively examined in this study, provide a standardized framework for common logistics procedures [10] [11]

Companies are increasingly confronted with sustainability challenges arising from climate change, fossil fuel depletion, and limited natural resources. Sustainability management aims to strike a balance between economic performance, social well-being, and environmental preservation. Environmental concerns have gained significant attention from governments and businesses worldwide in recent decades. While supply chain development has traditionally been driven by factors like cost and customer satisfaction,

there has been a growing recognition of the importance of environmental issues due to sustainability challenges.

Environmental considerations are now being integrated into supply chain models, such as incorporating environmental constraints, carbon taxes, emission trading schemes, and greenhouse gas emissions when selecting transportation options. Regulations have been established to encourage companies to adopt sustainable practices and improve their economic, social, and environmental performance. Moreover, it is widely acknowledged that environmental pollution can harm a company's reputation and profitability. Negative effects, such as the use of hazardous materials in supply chain operations, environmental pollution, excessive energy consumption, and carbon emissions, can have detrimental impacts on the industry's sales and profitability [12] [13] [14] [15].

The automobile industry and its supply chain have long been engaged in efforts to reduce CO2 emissions and contribute to a more sustainable world. A "green supply chain" aims to mitigate the negative environmental impact of the supply chain. This includes addressing issues related to hazardous materials, environmental contamination, energy usage, and carbon emissions. The primary objective of greening the supply chain is to integrate environmental best practices into regular supply chain operations [14] [16].

By carefully analyzing the applied terms and conditions in each sales contract – rules which each party are obliged to act accordingly -, it is possible to establish methodologies that assess logistic responsibility, plan for CO2 emissions, and address macro logistics at various levels of the supply chain. Considering the CO2 emissions generated by supply chains and their activities is essential in light of the current environmental state of our planet and the urgent need for environmental conservation.

## 1.3. Forvia ESD PC&L management

Since FORVIA ESD's business group is in charge of delivering finished goods directly to OEMs, who then carry out automobile total assembly, FORVIA ESD can be referred to as a Tier 1 supplier. Within the scope of this responsibility, produced seats are included. In view of the context for this study, it is critical to emphasize the framework FORVIA uses to carry out supply chain management and control on a regular basis.

All duties related to production control, customer volume analysis, Tier 2 supplier KPI management, and inventory management (concepts as safety stock parametrization, JNI maximum and minimum) are associated with the FORVIA PC&L department and its SCM responsibilities.

These tasks are completed regularly while recurring to the mySAP program. MySAP logs production confirmation and part consumption data every three minutes, allowing this program to track production status in real time. To determine the worth of work in progress,

costs are posted and parts that are consumed during assembly are deleted from the inventory count. By strengthening supply chain activities in demand planning, tracking and tracing of material deliveries, improving inventory accuracy across the plant, and reducing order-to-delivery time, this technology helps to significantly shorten the time it takes to reach the client. Additionally, it gets manufacturing orders with customer customizations from the corresponding planning systems of Forvia OEMs.

The orders comprise every component needed to construct each automobile; the volume of cars is broken down into sections according to BOM calculations: Larger suppliers receive the information via EDI, while smaller suppliers access the mySAP automotive supplier site, where OEMs post the requirements to offer up-to-date information on its delivery demands. OEM distributes long-horizon forecasts and short-horizon JIT delivery schedules to its suppliers. Suppliers can examine this information in real time, including release schedules, purchasing documents, invoicing, and engineering documents, using only an Internet browser.

To give the automaker precise information on part counts and delivery dates, suppliers send ASN information to customers when the parts are shipped. Parts are then received and sent straight to the production line after arriving at the customer's dock.

# 2. Literature Review

## 2.1. Incoterms: International Chamber of Commerce fair trading rules

As it has always been, efficient supply chain management depends on the negotiation and communication of logistics management choices between buyers and sellers of goods. The globalization and market liberalization have had a considerable impact on the acquisition and distribution of commodities. Global supply chains in many industries have changed dramatically and are still changing as a result of trade liberalization and the rise of emerging economies like Brazil, Russia, and India. Global trading has become increasingly complex as a result of the growth of international trade. In international business, the division of responsibilities between buyer and seller has begun to take up a significant amount of space. The ICC introduced a set of legal and contractual arrangements known as Incoterms to both buyers and sellers in 1936 in an effort to eliminate misunderstandings, legal disputes, and to prevent wasting money and time. These rules were intended to define the obligations for each party involved in a transaction. [17] [18]

The term "Incoterms" is an abbreviation of the phrase "International Commercial TERMS," and it designates a set of regulations put forth by the ICC. In the context of international trade, these regulations clearly identify and codify the rights and obligations of buyers and sellers. Incoterms address three major issues, according to a 1998 essay by Jimenez [19]:

1. Who is in charge of paying for transportation?
2. When can the risk of loss or degradation be transmitted in a transaction?
3. Who is in charge of import and export customs procedures?

Meanwhile, according to Chevalier (2000), Incoterms fundamentally allow for the precise definition of a number of factors, including the seller's delivery duties, the seller's transfer of risk to the buyer, the sharing of expenses between the two parties, and who is in charge of the transportation. It's vital to note that the kind, cost, quantity, and payment options of the products are the primary factors that must be considered when discussing export and import operations. Exporters must consider the Incoterms, as set by the ICC, while determining the product's pricing, which is crucial and requires time to decide. [18] [19] [20]

Although Incoterms are accepted by governments, courts, and transportation professionals all over the world, their use is not required. Companies are given the option to utilize or not employ Incoterms, at least theoretically. However, the absence of an Incoterm in a contract can pose serious issues for assessing the customs value of the goods, prompting

national governments to mandate their usage, effectively making them quasi-mandatory. It is also vital to companies to understand Incoterms correctly and completely to manage the business risks; international logistics companies, which have been providing services rather than transportation for year, are also guiding the importers or exporters in order to avoid any misunderstandings in the delivery types - for this reason, it becomes almost inevitable to use commercial terms [17] [18] [20]

Given this historical development in global trade, it is crucial to be aware of the regulations governing the obligations of both the exporter and the importer before engaging in any kind of international commerce transaction. Doing so helps prevent errors that could later result in additional costs or legal issues. By defining who is responsible for what and each step of the transaction, familiarizing yourself with Incoterms will assist to improve transactions that go more smoothly [21].

The most recent edition of the Incoterms (Incoterms® 2020) has been revised and divided into two groups that correspond to different types of transportation. There are seven possible Incoterms for any method (or modes) of transport out of the 11 rules, depending on the mode(s) of transport [22].

Figure 1, which serves as a reference for the seven Incoterms used for all modes of transportation, illustrates how today's incoterms connect buyers and sellers in terms of risk, costs, and insurance on their transactions [23].

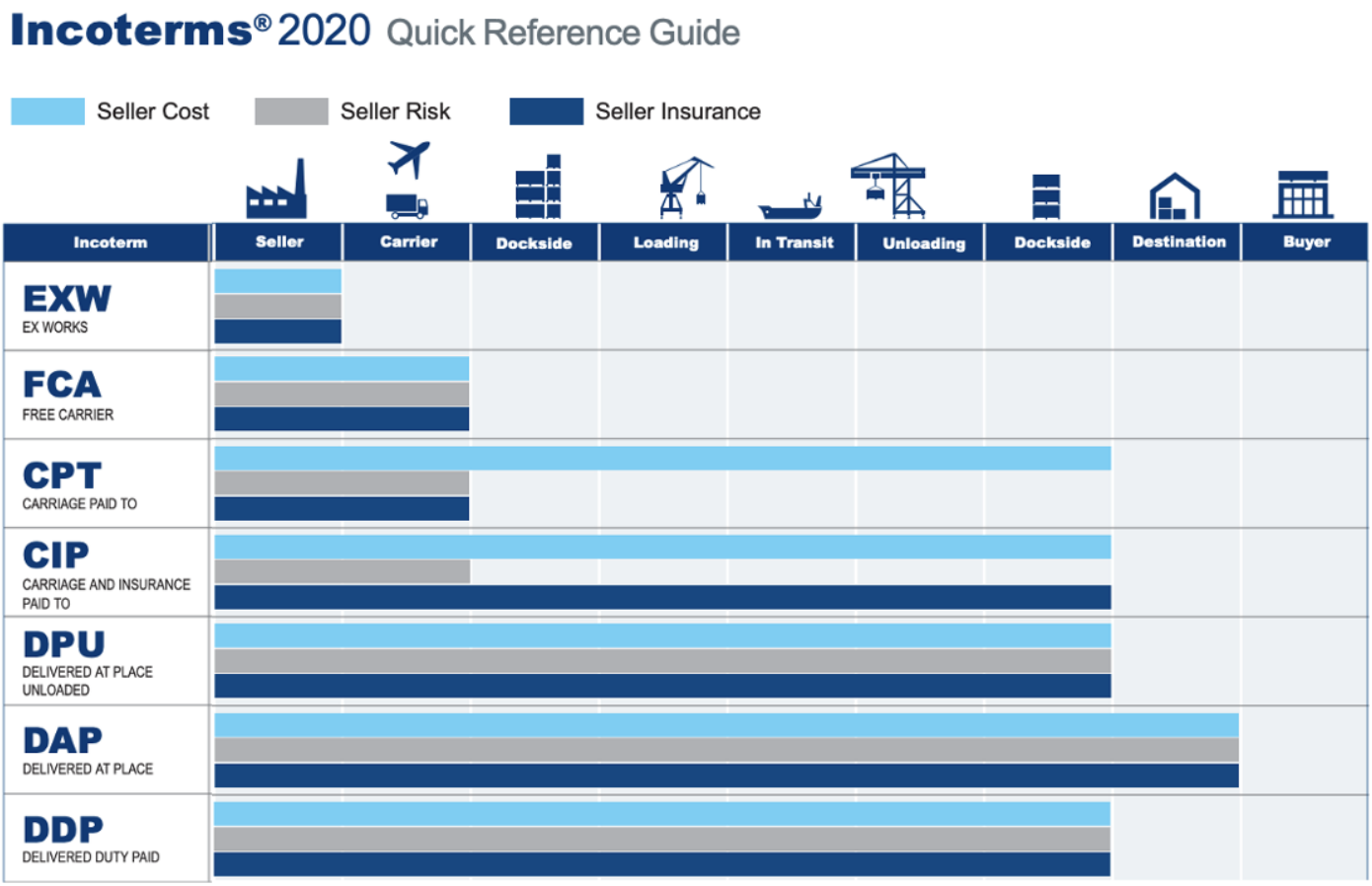


*Figure 1 - Seven Incoterms currently applied for all means of transportation [23]*

We can gain a feel of which responsibilities are assigned to each party of an International Trading Agreement by going into detail with each incoterm currently offered by the ICC. For instance, each Incoterm contains a statement about the seller's obligation to deliver the goods and commercial invoice in accordance with the terms of the sale agreement. Additionally, each Incoterm rule specifies which party is in charge of obtaining any export licenses or other official authorizations necessary for export and of completing the necessary customs formalities.

It is crucial for each side to understand what these incoterms do not cover, though [22]:

- Specify the items being sold and the contract price. - Address all terms of a sale.
- Outline the documentation that the seller must deliver to the buyer in order to speed up the customs clearance procedure in the buyer's nation.

- Address who is responsible if the items are not delivered on time, the delivery is delayed, or dispute resolution procedures are not followed. It should be noted that earlier editions of Incoterms are still usable, but doing so is not advised because they are unlikely to match current procedures. Therefore, it is crucial to include the revision year in the contract of sale in order to avoid any misinterpretation. This is a crucial factor to take into account, especially when a new revision is being implemented, as is the case at the time this paper is being written and the international trading community is going through a transitional period [24].

## 2.2. Incoterms development throughout International Trading history

Prior to the establishment of the International Chamber of Commerce, there was no body of regulations governing international trade between nations that could serve as a guide for importers, exporters, lawyers, carriers, insurers, and other parties involved in such transactions [25].

We may appreciate a group of businessmen, financiers, and traders who worked tirelessly to establish the International Chamber of Commerce in the wake of World War I in order to bring economic prosperity to the world. These businessmen recognized an opportunity to develop an industry standard that would later be known as the Incoterms regulations because there was no international system of laws to regulate commerce [26].

One of the first projects the ICC undertook after its founding in 1919 was to promote global trade. The world business organization set out to comprehend the terminology that merchants utilized in the commercial commerce at the beginning of the 1920s. This was accomplished by a study that focused solely on six widely used phrases in just 13 nations. Nevertheless, there have been numerous Incoterm modifications over the years. [26]

| Updates to Incoterms rules in the subsequent years | | | | | | |
|---|---|---|---|---|---|---|
| 1953 | 1967 | 1976 | 1980 | 1990 | 2000 | 2010 |

*Figure 2 - Table reviewing respective dates where there have been updated in Incoterms list and rules, throughout the years. [26]*

The fundamental driver behind these improvements was a shift in the dynamics between business partners. Additionally, there were instances when regulations were broken and others where loopholes were discovered. According to J. Ramberg, the original Incoterms clearly had a commodity trading focus and established the crucial delivery points at the ship's side or at the time the items were loaded onto the ship [27] [28].

These trade conditions were incredibly important since they were designed with the intention of applying a specific set of procedures that would allow one to allocate expenses, risk, obligations, and deliveries. Such conditions allowed the allocation of expenses, duties and hazards, paved the wayfor easier platforms for busines ties' developments and improved the industry's commercial operations' coordination [27] [28]:

In a world economy that is always evolving, using these Incoterms in international trade business transactions has shown to be a very good solution for our industry's concerns about cost reduction and liability settlement. [27] [28]

## 2.3. Incoterm change negotiation process and viability

When a buyer and seller negotiate Incoterms, they must come to an understanding regarding the precise conditions and obligations for the delivery of goods. Both the buyer and the seller should have a clear understanding of the applicable Incoterm and the responsibilities attached to it to ensure a successful transaction. The specific Incoterm chosen will have an impact on the duties for the transportation and delivery of the goods, as well as the cost and risk involved.

Before the final purchase agreement is established and usually during the early phases of the sales process, Incoterms are negotiated:

1. Choose the Incoterm(s) that are most appropriate for the transaction: The many Incoterms and their corresponding obligations and costs should be understood by both parties.
2. Discuss and negotiate the Incoterm(s): The buyer and seller should talk about which Incoterm(s) are best for the transaction and come to an agreement on them. The specifics of the Incoterm(s), such as the point of delivery and any other terms, should also be agreed upon.
3. Ensure that the agreed-upon Incoterm(s) are incorporated into the purchase agreement: Once the Incoterm(s) have been decided upon, they should be incorporated into the final purchase agreement.
4. Confirm the agreed Incoterm(s) in the shipping papers: To guarantee that all parties are aware of the agreed terms, the agreed Incoterm(s) should be confirmed in the shipping documents, such as the bill of lading or airway bill.

After an initial purchase agreement has been created, switching from one Incoterm to another can be difficult and may have substantial legal and financial repercussions for both the buyer and the seller.

Legal restrictions: Buyer and seller have a binding contract that details the exact Incoterm(s) that have been agreed upon once the first purchasing agreement has been signed. The contract would need to be renegotiated in order to change the Incoterm(s), which could

be time-consuming and expensive. Additionally, any modifications to the contract may need the consent of all parties involved, including any third-party financial institutions or logistics providers.

Financial restrictions: Modifying the Incoterm(s) after the initial purchase agreement has been made may have a major effect on the buyer and seller's financial arrangements. For instance, switching from a FOB (Free on Board) Incoterm to a CIF (Cost, Insurance, and Freight) Incoterm would put the seller in charge of paying for the cost of shipping and insurance rather than the consumer. This could have a considerable effect on the transaction's ultimate cost.

Constraints relating to logistics: Modifying the Incoterm(s) after the initial purchase agreement has been made may also affect the logistics of the transaction. For instance, if the parties have chosen an Incoterm of FOB (Free on Board), the seller is in charge of loading the goods onto the shipping vessel, and if the Incoterm is changed to CIF (Cost, Insurance and Freight), the seller is in charge of organizing the transportation of the products.

Overall, switching from one Incoterm to another following the creation of a first purchasing agreement is not an easy process and is to be avoided wherever possible. Before modifying the negotiated Incoterm(s), all parties should thoroughly evaluate the legal, financial, and logistical ramifications.

However, the industry's examination is to determine whether it is feasible to lower operating expenses while enhancing the quality of its services. Because of the constantly changing needs of the sector, analysis is done on a regular basis, despite the fact that altering a purchase agreement is time consuming and frequently expensive.

## 2.4. FCA and DAP incoterms

Customs play a crucial role in trade transactions, encompassing various aspects such as delivery location, method, evidence, transportation and insurance contracts, import/export customs clearance, risk, and cost allocation. Incoterms provide a standardized three-letter code that represents the agreed-upon rules between the contracting parties for the sale of goods. These codes serve as a universally recognized standard based on specific conditions [28] [29] [30].

The adoption of Incoterms aims to standardize transaction terms across different nations, mitigating the potential for trade disputes, reducing ambiguity resulting from varying interpretations, and ultimately saving time and resources [29] [30].

Forvia, in its dealings with its entire supplier chain, relies on the use of Incoterms to define the obligations that must be fulfilled. When establishing fair-trade agreements with specific suppliers responsible for providing products to Forvia's plants, the company adheres

to these regulations. These agreements are typically referred to as Scheduling Agreements (SLAs). The majority of SLAs between Faurecia and its suppliers are structured around FCA or DAP clauses. To clarify, let's consider Faurecia as the buyer and a specific supplier as the seller when discussing the differences between these two Incoterms.

**FCA (Free Carrier) Delivery**

Under the FCA (Free Carrier) Incoterm, the seller's responsibility is to deliver the authorized export goods to the carrier chosen by the buyer at the designated location in the destination country. Once the goods are loaded and made available for unloading at the carrier's disposal or at the disposal of a third party selected by the buyer, the risk and expenses associated with the goods transfer to the buyer [28] [29] [30].

In Forvia's supply chain, it is common for carriers to directly pick up the goods from the supplier's warehouse. Therefore, suppliers are not obligated to bear any transportation costs. The seller's costs primarily include packaging expenses and transportation costs from their warehouse to the designated location, where the carrier collects the goods for delivery to the buyer.

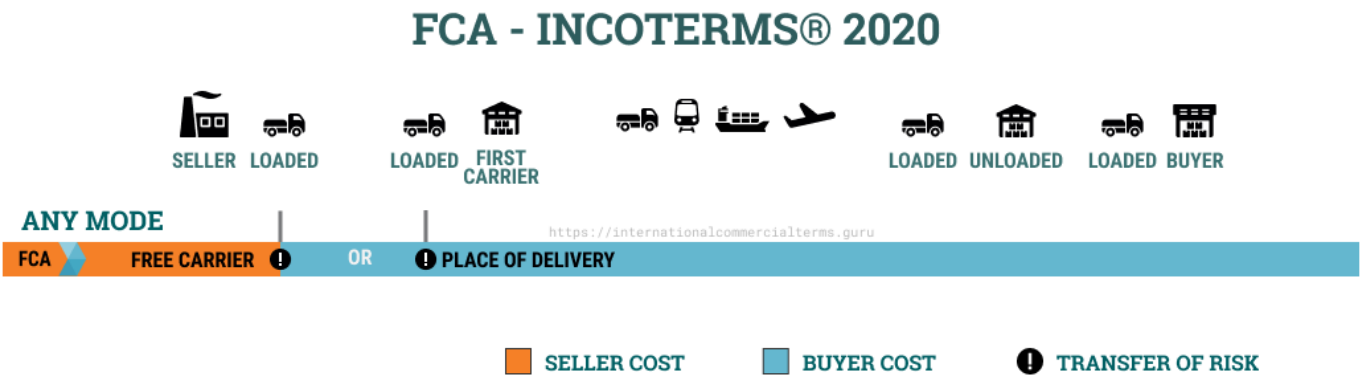


*Figure 3 - FCA Incoterm explained, acccording to the last updates from the International Chamber of Commerce [33]*

In accordance with the FCA Incoterm, the buyer is responsible for obtaining import-related license approvals and customs clearance, while the seller is responsible for completing export-related license approvals and clearance procedures. The roles of the buyer and seller in these processes are illustrated in the provided diagram [28] [31] [32].

If multiple modes of transportation are involved in the transaction for a specific commodity, the FCA trade rule can be applied to all of them. It is a highly flexible standard that applies in situations where the buyer arranges the main carriage. It is worth noting that

the FCA Incoterm has become the preferred choice for containerized goods, where the buyer organizes the primary transportation for delivery [31] [33].

**DAP (Delivery at Place): Delivery to destination**

The DAP (Delivered at Place) Incoterm specifies that the seller is responsible for ensuring that the goods are delivered to the designated place of destination in the importing country. If a specific point within the designated place has been agreed upon, the seller is responsible for unloading the goods from the mode of transportation upon arrival, provided that the goods have not yet obtained import clearance at that point [28] [31].

Under this Incoterm, the seller bears the expenses associated with the entire transportation process until the goods are delivered at the specified location. This includes costs related to export customs fees and any costs incurred in transit through a third country prior to delivery, such as duties, taxes, and charges. However, once the goods are delivered, the buyer becomes responsible for any costs incurred thereafter, as well as any subsequent expenses [28] [33], including costs associated with customs clearance for importing the items.

Figure 4 summarizes how the DAP incoterm operates between the buyer and seller [34].

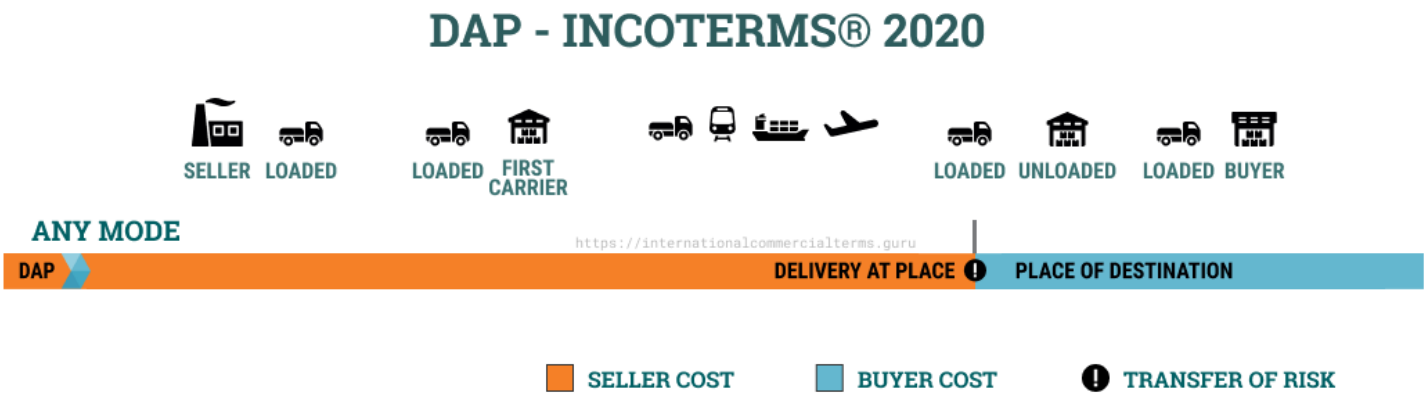


*Figure 4 - DAP Incoterm explained, acccording to the last updates from the International Chamber of Commerce [34]*

In the DAP (Delivered at Place) Incoterm, it is the seller's responsibility to engage in a contract for carriage to transport the goods to the specified location or arrange for transportation at their own expense. It is important to note that neither the seller nor the buyer are obligated to enter into an insurance contract under this Incoterm.

Furthermore, the seller is required to provide the buyer with delivery instructions and customary transit paperwork at their own expense, in order for the buyer to receive the

products. The buyer must accept the provided documents in order to complete the transaction [31]

### 2.4.1. Pros and cons overview on FCA and DAP incoterms

In a globalized automotive supply chain, the choice of the appropriate Incoterm for goods ordering and delivery depends on the specific advantages and disadvantages it offers to both the seller and the buyer [29] [33].

There are several factors that come into play when determining which Incoterms are most suitable, including [31] [33]:

- Travel time between the seller and the customer: The distance and time it takes for the goods to travel can influence the choice of Incoterm, as it impacts transportation costs and lead times.
- Importance of customs clearance: Depending on the nature of the goods and the countries involved, the ease or complexity of customs clearance procedures can be a significant consideration in selecting the appropriate Incoterm.
- Control and monitoring of merchandise: For valuable or sensitive items, the ability to track and monitor the position of the goods throughout the transportation process may be crucial. Certain Incoterms may provide more control and visibility in this regard.
- Negotiating price and responsibilities: The determination of who will be responsible for specific shipping-related tasks, such as arranging transportation, insurance, or customs clearance, can impact the overall price negotiations between the buyer and the seller.

In this particular case study, the focus will be on FORVIA's role as the buyer in these transactions, highlighting the considerations and decisions they need to make regarding the choice of Incoterm.

**DAP in supply chain – pros and cons overview:**

In the case of DAP (Delivered at Place), which stands for "Delivered at Place" in shipping jargon, the seller assumes responsibility for all expenses and risks associated with delivering the goods to the agreed-upon final destination, often the buyer's premises.

**Advantages**:

- Clear liability for additional costs: One of the key benefits for the buyer when exporting under the DAP Incoterm is knowing who is responsible for covering any additional expenses incurred during the transportation process. The seller is accountable for paying these costs, reducing the buyer's financial burden.

- Low liability for the buyer: According to the International Commerce Center, once the goods are made available to the buyer, they assume all risks and losses related to the cargo. The buyer typically gains access to the shipment at their own warehouse, while the seller is responsible for any additional expenses during shipping. This reduced liability can be advantageous for buyers.
- Cash flow and inventory management: DAP can assist buyers in managing cash flow and inventories, especially for expensive items that require frequent reorders. By negotiating DAP Incoterms with sellers, the buyer can rely on the seller to handle the shipping, and payment is only made when the shipment reaches its destination. This arrangement allows buyers to have regularly ordered goods delivered to a bonded warehouse near their location, enabling them to reorder efficiently.

**Disadvantages:**

- Customs clearance delays and costs: Although DAP stipulates that the buyer is responsible for paying import taxes, duties, and clearance fees, customs clearance often occurs before the cargo reaches the buyer's designated location. Delays in customs clearance can result in additional expenses borne by the buyer, leading to potential delays, damage, or detention of the goods.
- Lack of tracking and visibility: A drawback of relying on DAP delivery is the limited tracking and visibility over the ordered products by the supplier. Since the seller is responsible for arranging the shipping, they are also responsible for monitoring the products during transit. This lack of visibility can be a constraint when calculating forecasted stock, assessing production risks, and managing inventory needs.
- Seller's risks: Sellers may perceive DAP as a risk, particularly when shipping to new customers. One of the major risks for sellers is the potential refusal by the buyer to pay import charges, which could result in the seller losing their shipment. To mitigate these risks, sellers may increase deposits or fees to offset the potential losses.

These advantages and disadvantages highlight the considerations that both buyers and sellers need to take into account when deciding to use the DAP Incoterm in their transactions [31] [33].

**FCA in supply chain – pros and cons overview:**

The seller is responsible for the majority of the export data at the point of origin, as stated in the FCA incoterm. In addition, the buyer is responsible for certain origin-related processes, such as import and export formalities, transit operations, and transportation charges.

Now let's examine the advantages and disadvantages of FCA Incoterms:

**Advantages:**

Control and paperwork relief: With FCA Incoterms, customers have more control and are relieved of the paperwork load. The buyer has the freedom to choose the desired carrier or mode of transportation, which helps avoid delays and saves money. Additionally, the seller is responsible for managing the export-related paperwork, reducing the administrative burden on the buyer.

Payment flexibility: The method of payment is advantageous for buyers under the FCA agreement. The payment period may start when the items are delivered to the customer's address. If the items are not yet delivered, the vendor will have to wait until they reach their destination before receiving payment.

Visibility and tracking: Unlike the DAP Incoterm, FCA provides greater visibility and tracking of goods during transit, making it safer for the buyer. Since the buyer selects the mode of transportation and carrier, they have the necessary contacts and connections to ensure timely delivery to the correct location.

Negotiating lower prices: Buyers can negotiate lower prices for the items they are purchasing because they are responsible for arranging the entire transport and paying all fees related to the shipments. By managing the appropriate carrier and transport options, buyers have the opportunity to save money on purchases and improve the quality of their services. This Incoterm allows buyers to renegotiate prices with the seller for their services/sold goods.

**Disadvantages**:

Buyer participation at the point of origin: One of the downsides of FCA is that the buyer is still involved at the point of origin. This means the buyer must pay for loading and terminal charges. If any issues arise during this process, it can cause delays in delivery, as the buyer would have to wait for the seller to resolve the problem.

Recommended for container shipments: According to the International Chamber of Commerce (ICC), FCA is recommended for shipments using containers. This is because containerized goods can be transported directly from the point of sale to the final destination, with the terminal being the agreed-upon place. If the agreed-upon place is not the terminal, the risk is transferred to the buyer only when the products arrive at the port. The cost of unloading at the specified place becomes the buyer's responsibility.

Inventory management and payables: Under FCA agreements, the goods are already accounted for as internal stock for the buyer as soon as they are picked up at the seller's location and start their journey to the buyer's destination. Although not physically present, they are considered part of the buyer's inventory. Therefore, the buyer must account for the ordered products in transit as if they are already in the warehouse, affecting inventory management and stock currency balances.

These advantages and disadvantages highlight the considerations that both buyers and sellers need to take into account when deciding to use the FCA Incoterm in their transactions [31] [33].

## 2.5. Automotive Industry and its Supply Chain – in depth

The automobile industry is a significant contributor to global employment, and its importance stems from its complex value chain and connections to domestic and global economies. In the twenty-first century's shifting business environment, companies in the automotive industry face challenges such as globalization, economic uncertainty, new technologies, and increasing customer demands.

With fierce competition and fluctuating market demand, customers have become more demanding, leading to increased preferences. The current market is characterized by shorter product lifecycles, intense competition in product introductions, and demand volatility, making it challenging to predict and manage life-cycle demand effectively. Automakers, producing vehicles worldwide, encounter complexities in their supply chains, which often hinder profitability and shareholder value. These challenges include lengthy order-to-delivery lead times, erratic production schedules, excess inventory throughout the supply chain, protracted demand planning cycles, and a lack of supplier visibility.

In recent years, there has been a significant shift in vehicle production, with self-assembling manufacturers of metal and plastic parts being replaced by spin-off manufacturing companies that produce in-house parts as independent entities. This shift necessitates a more skilled workforce. Most new vehicles are now produced on moving assembly lines using highly structured and refined processes.

The aforementioned difficulties highlight the need for adaptability and responsiveness to consumer demand for car manufacturers to thrive – this is where supply chain management jumps in.

Supply chain management (SCM) was introduced in the automobile industry to adopt leaner processes and enhance industry efficiency. SCM principles, such as just-in-time (JIT) manufacturing, supplier base rationalization, virtual inventory, outsourcing, customized and global networks, reduction of buffers, and fewer distribution facilities, have facilitated overall industry improvements [6] [7].

Figure 5 provides an accurate depiction of the supply management connections in the modern era. [52]

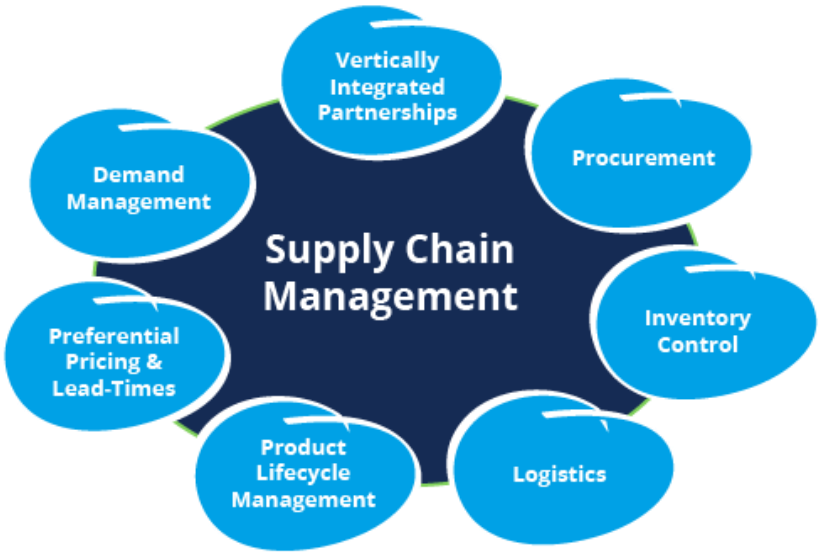


*Figure 5 - SCM concepts and associated activities applied on industry, in general [52]*

SCM relies on two fundamental components: a collective effort by multiple entities to ensure product delivery to customers, and control and monitoring of each step in the process to directly impact the quality of goods or services delivered to end users. The methodology behind SCM encompasses planning and managing all activities related to sourcing, procurement, logistics, and distribution, emphasizing synergy among suppliers, third-party service providers, and customers to align supply and demand within and across organizations [8].

Decision-making in SCM can be categorized into operational and strategic decisions. Operational decisions focus on daily activities, managing the flow of goods and services efficiently and effectively within the tactically planned supply chain. Strategic decisions, on the other hand, pertain to corporate strategy and the design of supply chain architecture,

requiring a longer time horizon. The decision-making process in supply chain management involves trade and communication agreements among all participating parties, driving industries to seek better operational capacity and efficiency. By assessing the requirements of all partners and defining contractual obligations within the supply chain, businesses have the opportunity to enhance services while reducing operational costs [7] [8] [9].

Therefore, the crucial role of supply chain management (SCM) in improving automotive performance cannot be overstated. Authorities and organizations must recognize supply chains as sources of competitive advantage for the automotive sector.

By effectively managing their supply chains, automotive companies can enhance operational efficiency, reduce costs, optimize inventory levels, improve production planning, and strengthen relationships with suppliers. This enables them to respond more effectively to customer demands, shorten lead times, and achieve higher levels of customer satisfaction. The integration of SCM practices and technologies is crucial for achieving these benefits and driving the success of the automotive industry.

In conclusion, the automotive industry operates within a complex and dynamic environment, necessitating the recognition of supply chains as a vital component for competitive advantage. By addressing the challenges and embracing effective supply chain management practices, automotive companies can enhance their performance and meet the ever-evolving demands of the market [35] [38] [39] [40].

### 2.5.1. Structural analysis on today’s automotive industry

Since the creation of the first automobiles over a century ago, the automotive industry has been at the forefront of innovation and technological advancements. The industry continues to be shaped by various innovations, including the development of new ultra-lightweight body materials, the rise of battery electric vehicles (BEVs), and advancements in wireless communication technologies [41].

In the automotive sector, mass production is a widely used production method. Traditional mass production relies heavily on an organization's ability to accurately predict demand, which then guides the operational and production decisions of the organization. Figure 6 provides an overview of the different components within this vast industry, along with the ultimate goal of delivering the finished product to customers [42] [43]:

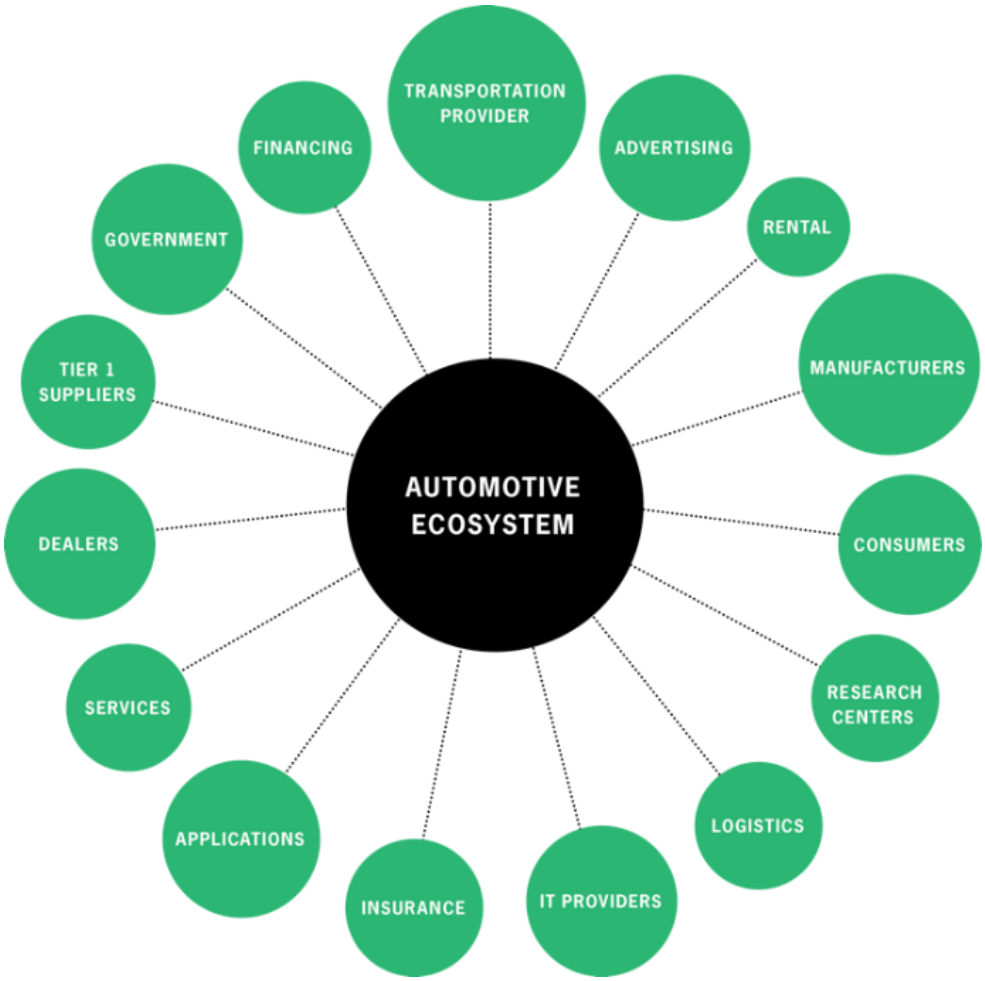


*Figure 6 - Overview of all intervenients and participants that have impact on the automotive ecosystem, from a global standpoint [43]*

The automotive industry encompasses various stages, including research and development, design, engineering, manufacturing, assembly, distribution, and sales. Each stage requires coordination and collaboration among multiple stakeholders, including automakers, suppliers, dealerships, and customers. Effective supply chain management plays a crucial role in streamlining these processes and ensuring the timely delivery of high-quality vehicles to the market.

As the industry evolves, new technologies and trends continue to shape its landscape. The adoption of ultra-lightweight body materials, such as advanced composites and aluminum alloys, contributes to improved fuel efficiency and reduced emissions. Battery electric vehicles (BEVs) are gaining traction as a sustainable alternative to traditional internal combustion engine vehicles, addressing environmental concerns and promoting

cleaner mobility. Furthermore, advancements in wireless communication technologies enable features like connected cars, autonomous driving, and enhanced vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication.

These innovations not only drive improvements in vehicle performance, safety, and efficiency but also present new challenges and opportunities for the automotive industry. Manufacturers must adapt to changing customer preferences and market demands, invest in research and development, and embrace emerging technologies to stay competitive in this rapidly evolving landscape.

In conclusion, the automotive industry has a long history of innovation and technological advancement. From the introduction of the first automobiles to the current era of lightweight materials, electric vehicles, and wireless communication, the industry continues to push boundaries and shape the future of transportation. Effective supply chain management, along with a keen focus on emerging trends and customer demands, will be crucial for automotive companies to thrive in this dynamic and competitive environment [41] [42] [43].

Over the past two decades, the automobile industry has experienced a significant transformation in its operational approach. Traditionally, the industry operated under a "push" model, where production was driven by forecasts and historical data. This forecast-driven production system utilized estimates and historical trends to create a production plan and relied on existing configurations to manufacture goods for stock. Teams from various departments, including design, engineering, finance, and manufacturing, used projections from marketing and sales to determine, produce, and simulate production volumes based on their best estimates of market demand.

However, as the market landscape rapidly changes and customer demands become more diverse, the traditional forecast-driven manufacturing approach may no longer be as effective. The industry is witnessing a shift towards mass customization and a demand for more personalized products, requiring a more agile and responsive production system. In this context, a customer-order-driven manufacturing technique, also known as a pull system, is gaining prominence.

In a customer-order-driven manufacturing system, the entire operation is driven by individual customer orders rather than forecasts. The focus is on quickly producing items in response to specific customer orders, eliminating the need for large stockpiles of inventory. This approach enables automakers to be more flexible, responsive, and efficient in meeting customer demands. By aligning production with actual customer orders, the industry can reduce lead times, minimize excess inventory, and improve overall operational efficiency.

This shift from a forecast-driven "push" model to a customer-order-driven "pull" model reflects the industry's recognition of the need to adapt to changing market dynamics.

Customers now expect greater customization options and shorter delivery times, and the pull system allows manufacturers to cater to these evolving demands. By producing vehicles based on actual customer orders, automakers can avoid the risks associated with forecasting errors, reduce costs associated with inventory holding, and enhance customer satisfaction through timely delivery of customized products.

However, transitioning to a customer-order-driven manufacturing system presents its own set of challenges. It requires close collaboration and coordination among different departments, suppliers, and production facilities to ensure smooth order fulfillment. Additionally, the shift may require changes in the production process, supply chain management, and IT systems to support real-time data exchange and efficient production scheduling.

In conclusion, the automobile industry has experienced a transformative change in its manufacturing approach over the last two decades. Moving away from the traditional forecast-driven production model, the industry is embracing a customer-order-driven manufacturing technique, or a pull system. By aligning production with individual customer orders, automakers can meet the demands of mass customization and respond more effectively to rapidly changing market conditions. This shift enables greater agility, reduced inventory levels, improved operational efficiency, and enhanced customer satisfaction [42] [44] [45].

### 2.5.2. Logistical structure applied to automotive industry (SCM)

Supply management and physical distribution management are integral components of the automotive industry, given the extensive supply chain involved in manufacturing vehicles, from raw material suppliers to the assembly of complex electronic and computing technologies. The supply chain encompasses suppliers (tier 1–3), original equipment manufacturers (OEMs), distribution hubs, dealers, and end customers. OEMs typically generate around 30 to 35% of the value themselves and rely on suppliers for the remaining portion. Manufacturers purchase various subassemblies from suppliers, including doors, seats, engines, and electronics. To facilitate the outsourcing of subassemblies, a new infrastructure is being developed to support the design, procurement, and transportation operations of manufacturing companies. Automotive manufacturers must enhance their development and management skills, leveraging advancements in computer-aided design (CAD), computer-aided process planning (CAPP), computer-aided manufacturing (CAM), computer-aided engineering (CAE), concurrent engineering (CE), product data management (PDM), and business process engineering. These advancements enable manufacturers to increase their innovation capacity, bring cars to market faster, and reduce errors. [46] [47] [48]

## 2.6. Globalization standpoint in current industry - environmental impact generated by globalized trading

The challenges related to trade and the environment are complex and multifaceted, with environmental concerns impacting production costs, trade patterns, industry location, and trade profitability. Environmental considerations have gained increasing importance in various aspects over the past four decades, coinciding with the automotive industry's strong drive towards globalization since the 1980s. Furthermore, there has been a significant increase in global mobility in recent decades. Although birth rates are declining in industrialized regions, the global population continues to grow. It is projected that the world population will reach approximately 9 billion people by 2050, with about 95% of that growth occurring in emerging and newly industrialized countries. In fact, India is expected to surpass China as the most populous nation. These trends have led to a sharp rise in transportation demand in these countries.

The automotive industry has experienced significant revenue growth since the global financial crisis of 2008, as depicted in Figure 7. This growth reflects the industry's ability to adapt and thrive amidst changing economic conditions. [54] [55] [57]

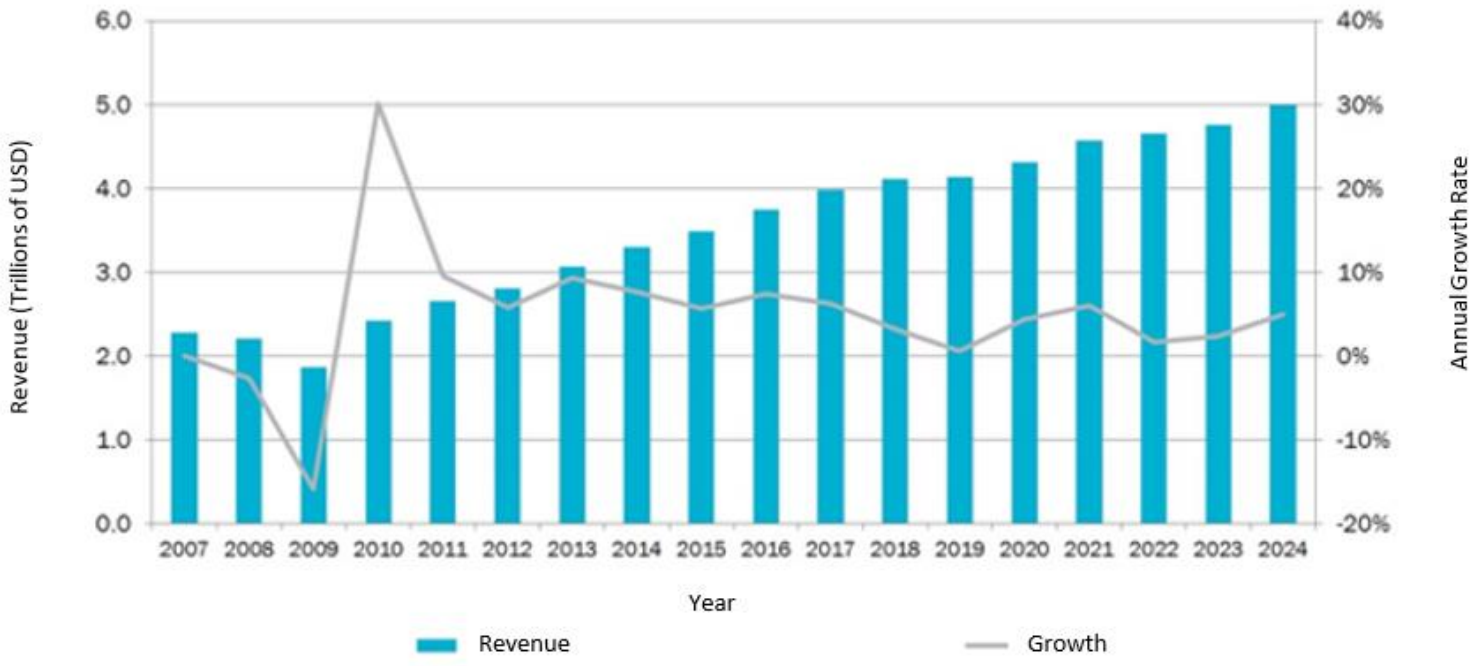


*Figure 7 - Automotive industry revenue analysis, since the 2008 economic crisis [55]*

The automobile sector has witnessed prosperity and market expansion due to globalization strategies and the entry of new players, resulting in a revenue increase of approximately 30% since the 2008 financial crisis. However, continued globalization has brought about more complex challenges that will significantly impact the industry's future. Ongoing crises worldwide often lead to reduced global market demand, excessive production capacity, and volatile raw material prices. Furthermore, global automotive companies face new local regulations and import regimes that can either restrict or enable their market access as they expand into new markets. Balancing emission reduction efforts with the growing demand for mobility worldwide is a critical goal for these companies. [56]

It is important to address the worsening issue of traffic congestion by implementing efficient mass transit systems and intelligent traffic management. The transportation and logistics industries are experiencing rapid growth in nearly every region of the world. Expansion rates in the transport sector range from 5% for industrialized nations to 5-8% for emerging regions. As major automotive OEMs increase their sourcing activities in low-cost countries, it is expected that global transportation demand will continue to rise in the coming years. [58]

Green supply chain management is receiving increasing attention in response to these challenges. Measures such as local consolidation centers, supply chain optimization, and collaboration in bundling transport volumes can reduce costs while also having favorable environmental impacts. Suppliers delivering assembled modules or components can adopt logistics concepts like cross-docking to cut costs and improve customer service, even if they are located near automotive OEM factories. Investment in low- or zero-emission technologies such as fuel cells, electric vehicles, and hybrids, as well as advancements in lightweight materials, should be prioritized. Product design should focus on waste elimination throughout the product life cycle, and factories should be optimized for both production efficiency and repurposing efforts. [58] [59] [60]

### 2.6.1. Incoterms and environmental impact

Presently, international transportation activities contribute to approximately one-third of all emissions related to global trade, although the specific figures vary across regions. China and India account for around 14% of export emissions, while the United States is responsible for nearly two-thirds of such emissions. Freight transport for trade is responsible for over 30% of all transport-related CO2 emissions from fuel burning, amounting to more than 7% of global emissions. Among different transportation modes, road transport stands out as it has higher emission intensity per tonne-kilometer and occupies a significant share in the transport modal mix. In fact, road transport alone contributes to over half of all CO2 freight emissions related to trade. Additionally, since road transport often handles the first

and last legs of international supply chains, it accounts for about 10% of international trade (measured in tonne-kilometers) within domestic borders, yet it contributes to approximately 30% of CO2 emissions. [61] [62]

The CO2 emissions associated with the transportation sectors used in the automotive industry supply chain are shown in Figure 8 [60].

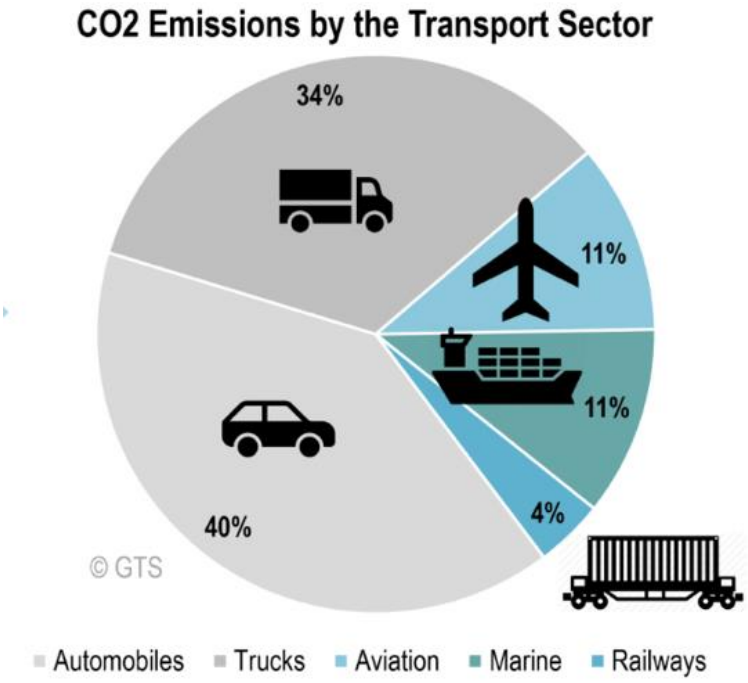


*Figure 8 - Representative chart for CO2 emissions associated to each transport sector used in current industry's trading [59]*

International efforts and agreements often overlook emissions from international transportation, but there is an increasing recognition of the need to establish a database, standardized measurement techniques, and an effective monitoring system to better assess the environmental impacts of global freight movement. Creating a comprehensive understanding of emissions associated with international freight transport has become crucial in recent decades [61] [63] [64].

In the realm of logistics, the allocation of emissions in international trade is essential, considering the various responsibilities and roles of logistics intermediaries. The allocation should be based on an analysis of logistic responsibilities and the functions performed by these intermediaries. The Incoterms, widely used to define liability in international delivery, play a significant role in determining the allocation of expenses, duties, and responsibilities

related to logistics. These regulations also determine the division of responsibility between trade partners concerning transportation mode, route selection, shipment characteristics, and resulting logistics-related emissions [61] [63] [64] [65].

To manage international delivery and gain a competitive advantage through logistical expertise, the responsibility for delivery is often transferred from the selling party to logistics service providers, freight forwarders, and other intermediaries. These intermediaries act as intermediaries between all entities involved in the supply chain, including importers, exporters, carriers, ports, logistics hubs, warehouses, and customs. The "7R principle" (right time, right place, right pricing, right recipient, right product, right quantity, and right condition) is commonly used to measure logistical goals, and the capabilities and skills of logistics intermediaries directly impact the division of logistical tasks among trade parties [55] [66] [67].

As previously discussed, selecting the appropriate Incoterm clause in the sales contract aims to enhance flexibility in logistics routing, ensure consistency, and provide financial benefits. It also seeks to reduce risks, lower costs, and improve overall delivery efficiency for the end user. However, when using Incoterms, it is crucial to consider the environmental impact of route parametrization and the involvement of intermediate partners in the supply chain flow [55] [68] [69]

A research study conducted by the University of Novi Sad (Serbia) proposed an original approach using origin-destination-Incoterms rules-transport mode analysis to estimate and allocate CO2 emissions related to international trade-related transportation. The method considered freight transport volumes by each mode of transportation and utilized a comprehensive dataset on bilateral trade flows between Serbia and 41 European countries in 2016. The study aimed to determine the existing and predicted CO2 emissions resulting from changes in delivery obligations. The study introduced the "index of responsibility for transport emissions" (RTE-index), which assigns a value between 0 and 100% to each party in bilateral trade, representing their cumulative share of responsibility for CO2 emissions across both trading directions and major transportation modes [55].

It is worth emphasizing that Incoterm clauses in sales contracts can be transformed into meaningful sustainability indicators and used to determine liability for transport emissions based on the study's findings. For example, the application of the RTE-index as a supportive indicator has helped determine the percentage of responsibility for trade-related CO2 emissions between Serbia and 41 other countries. This facilitates the identification of influential trade relationships and enables the search for solutions to be implemented in the supply flow. Such changes can be facilitated by introducing new Incoterm clauses that reallocate transport responsibilities as needed [55].

## 2.7. Incoterms impact in automotive supply chain

Globalization and liberalization of automotive markets had a big impact on procurement and distribution of goods throughout the industry. With the arrival of trade liberalization, as well as global economies' development, – e.g., Brazil, Russa, India – global supply chains went through ongoing changes across several industries. From an operational point of view, the distribution and supply networks need to be reprogrammed and re-optimized as a result of an increased need of satisfying complex demands from, not only customers, but also retailers. [70]

To keep up at top level on a truly globalized stage, companies are seeking for new partners that can generate savings in operating costs – such partners have been found in Asia, mostly. This practice, named as "offshoring" or "global sourcing", can result in trading savings regarding operating cost in exchange of increases in transportation, inventory and handling costs. Companies are also increasingly focusing on their core competencies – it can be either manufacturing or assembly of goods, or the design and marketing of products. Competencies like these include the supply and distribution of goods, as these activities get more and more outsourced to third party organizations that are well-established in logistics. In this context, it is essential to get a grasp of the rules that control international trade and how each party responsibilities are shared between individual members taking part in global supply chains. This is where Incoterms come into play. [70]

Incoterms and export play vital roles in all industries, particularly those engaged in production that rely on importing goods or raw materials for manufacturing and exporting finished products worldwide. In international commerce, especially in developing nations, trade costs and production costs are key factors influencing competitiveness [71] [72] [73].

### 2.7.1. Overview on the need for incoterm application in the automotive supply chain

A semi-assembly refers to a first-tier supplier that provides a functionally independent finished good during the assembly of an automobile, while a secondary parts cooperation company acts as a second-tier supplier, supplying specific goods to the first-tier supplier in the automotive part cooperation supply chain. The term "third-party cooperation company" refers to a business that supplies goods to the second-tier supplier. Automotive component producers support automobile manufacturers and automotive assembly businesses by timely providing goods to both local and foreign clients [76] [77].

The globalization of the economy in recent decades has brought about changes in supply chains, necessitating more effective supply chain networks to keep up with increased

trade. As manufacturing and consumption of goods are no longer confined to a single region, longer and more complex supply chains have emerged, impacting the management of supply chain conditions [78] [79].

In the context of growing supply chains, it is crucial to protect their financial value and advantages in the realm of global trade. By optimizing transportation flows within the supply chain, the value of commodities and products can be enhanced, leading to the adoption and improvement of Incoterms. Understanding them can also help avoid financial losses caused by delays or improper management of items. It is important to emphasize that leveraging Incoterms to achieve financial gain and minimize unpredictability is a key strategy. This endeavor represents the drive to enhance international commercial terminology, i.e., Incoterms. It is also essencial to highlight that negotiating trade agreements is a complex and diverse process due to the involvement of numerous suppliers and customers. It encompasses aspects such as delivery, transportation costs, transportation risks, and contractual obligations. To address these complexities, a trade agreement like the ICC Incoterms becomes indispensable as it establishes internationally recognized responsibilities, obligations, transit liability, and compensation Let's have an overview of such impacts that Incoterms can have [71] [74] [75] [78] [80] [81] [82]:

a) Risk and Cost Allocation: Incoterms help determine who bares the risk and cost associated with transportation, insurance, and customs clearance. For example, under the EXW (Ex Works) term, the buyer takes on most of the risks and costs, while under the CIF (Cost, Insurance, and Freight) term, the seller is responsible for arranging insurance and freight costs.
b) Logistics Planning: Incoterms influence the logistics planning process in the automotive industry. Terms like FOB (Free on Board) or CPT (Carriage Paid To) determine where the transfer of responsibility and risk takes place, impacting the selection of transportation modes, routes, and service providers.
c) Supply Chain Efficiency: the choice of Incoterms can affect supply chain efficiency. Terms like DPP (Delivery Duty Paid) place more responsibility on the seller, streamlining the import process for the buyer. On the other hand, terms like FCA provide flexibility in selecting the mode of transportation and carrier.
d) Legal Compliance: Incoterms help ensure legal compliance in international trade. They provide clarity and common understanding between parties, reducing the risk of disputes and misunderstandings related to shipping terms and obligations.
e) International Trade Negotiations: Understanding Incoterms is crucial during negotiations between automotive companies in different countries. The terms agreed upon can impact pricing, competitiveness, and market access.

## 2.8. Multi-Criteria Decision-Making: Analytical Hierarchy Process

Incoterms are contractual terms utilized in international sales agreements between nations. They define the risk associated with a product, specifying the obligations of the seller and the potential impact on the buyer's responsibilities. These terms encompass aspects such as transportation, insurance, and delivery of the finished goods being traded between the buyer and seller. However, selecting the appropriate Incoterms can often be challenging due to a lack of understanding of the relevant supply chain dynamics. The preferences of supply chain stakeholders play a crucial role in determining the suitable terms to be employed [71] [83].

Having established and up-to-date selection tools is essential for businesses. Managers need to carefully consider various factors when making decisions to enhance corporate efficiency. A study titled "Decision-Making on Incoterms 2020 of Automotive Parts Manufacturers in Thailand," conducted by Burapha University and published in The Journal of Asian Finance, Economics, and Business, explored the overall impact of Incoterm choices and application on the automotive industry. The study employed a combination of qualitative and quantitative research techniques, utilizing the Analytical Hierarchy Process (AHP) to prioritize the significance of key aspects. Its primary objective was to investigate decision-making within the framework of pre-agreements [71] [83].

The Analytical Hierarchy Process (AHP), credited to Thomas Saaty, is a decision-making approach that addresses decision problems in multivariate contexts. Its primary purpose is to offer solutions by contrasting multiple options against various criteria to achieve specified objectives. By utilizing information or expert opinions to evaluate the relative contribution or relevance of qualities, this technique allows decision-makers to tackle complex decision-making problems with diverse selection criteria (Trang & Do, 2020).

At the foundation of the AHP is the measurement process, particularly on a ratio scale. Decision weights and priorities are established based on the decision maker's assessments of how each item in a decision problem compares to others at the same level of the hierarchy. This measurement theory employs pairwise comparisons and relies on expert judgments to derive a priority scale. The hierarchical structure is designed to mimic human thinking and replicate the human decision-making process; it also incorporates different levels based on the complexity of the problem [84] [85]. According to the study conducted by Burapha University, this method was utilized to assess which Incoterm should be applicable taking into account several factors and criteria that have a strict impact in the industry; the framework for this decision-making process (applied in this case study) can be seen in Figure 9.

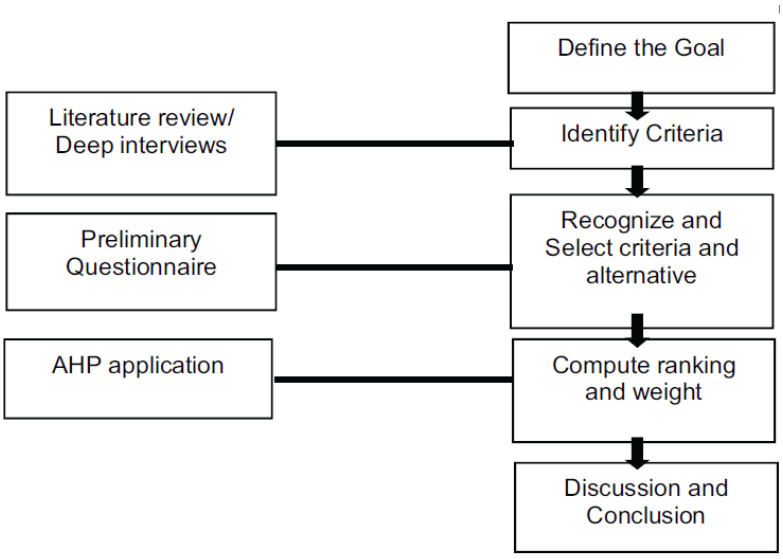


*Figure 9 - Research framework for investigation regarding the applicatoin of the AHP methodology [70]*

Based on the study, four primary factors were identified: operational costs, negotiating strength and cooperation, operational time, and knowledge and comprehension. The study focused on four contracts that utilized the most commonly used Incoterms: DAP, FCA, FOB, and CIF [71].

To summarize the findings of the study conducted by Burapha University, it was shown that FCA and DAP are the two preferred Incoterms for the majority of cases; FCA is favored over DAP due to factors such as operational costs and visibility within the supply chain [71].

# 3. Methodology

## 3.1. Forvia supply chain incoterm selection – PC&L routines case study

Forvia, a business that produces and distributes completed items to automobile OEMs, is constantly striving to enhance its offerings in order to stay up with the constantly changing demands of the sector. Because of this, the objective of this paper is to help readers make good decisions (regularly) regarding the analysis of their supply chain and selection of the purchasing agreements to be made with their supply base. In other words, this paper will help readers determine the most appropriate Incoterm to be used in each international transaction they enter into between their company (the buyer) and each supplier (the seller).

Forvia conducted an analysis of their present supply chain's cost, logistics, and risk as well as any potential future modifications to that supply chain in order to produce this assessment and establish which Incoterm is best for their company. There are a number of crucial indications that must be observed with regard to the logistical control involved in this normal procedure, and they are listed below:

- Current stock: stock that is available at the time of the coverage analysis.

- Safety stock: a quantity of inventory kept on hand that is assessed to be necessary for daily production security in order to respond to customer changes and supplier delivery delays.

- Minimum stock: The lowest amount that can be used as production-ready stock. Below this point, the facility lacks the ability to respond quickly to any limitations (client variations, transportation delays, stock inconsistencies), which has an immediate negative impact on the supply chain.

- Maximum stock level required in the plant. Above this point, the plant begins to incur unnecessary expenditures due to unused parts and storage problems in the warehouse.

- MOQ stands for minimum order quantity and refers to the total number of pieces that can fit inside a single handling unit (such as a carton box, metal box, or pallet).

- Requirements: the amount anticipated to be used daily in the production line

- Projected receipts: projected deliveries of items to the factory

- Projected stock: calculated at the end of each day (projected stock = present stock minus requirements plus anticipated receipts).

The method of supply chain analysis and the reasoning behind the selection of the Incoterm will subsequently be covered in this case study. The logistical procedures and daily

routines pertaining to production control and supply chain visibility on acquired commodities required to ensure client demand form the basis of this case study. Below are two distinct situations for the supply of a specific finished good to a specific Forvia plant (for each scenario, each supplier has a different location than the other, as well as both Forvia's plants). A straightforward coverage file has been created for each case study in order to demonstrate this approach.

**Scenario 1**

Let's use as an example, a supplier who sells small plastic parts – for example, pieces for positioning the height of a seating's headrest.

- Supplier is located in France, as well as Forvia plant – total transit time of 10 hours.
- Number of deliveries per week: 1
- Delivery date: Wednesdays
- Low raw material cost (0,35€ per plastic part)
- Average daily need to consume 150 of these plastic parts. Daily safety stock in plant is parametrized at 2000 plastic parts.

**Scenario 2:**

For our 2nd example, we will be using a supplier responsible for delivering frames – metallic structure used as basis for the entire seat production.

- Supplier based in Poland, while Forvia plant is based in Slovakia – total transit time of 12 hours.
- Number of deliveries per week: 5
- Delivery date: Monday, Tuesday, Wednesday, Thursday, Friday
- Expensive raw material (30€ per frame)

Average daily consumption of 150 frames. Daily safety stock is parametrized at 225 frames.

## 3.2. Incoterms environmental impact on Forvia supply chain – carbon footprint case study

The amount of greenhouse gases released into the environment as a result of an organization's operations is measured as the carbon footprint. Regardless of Forvia's goals and decisions about its position as a global leader in the provision of completed goods to automobile OEMs, the firm is also committed to providing sustainable solutions to our mobility sector and the current situation.

In order to examine the carbon dioxide emissions associated with its transport flow, Forvia also undertook a case study. This case study focuses primarily on the impact of the Incoterm adjustments from DAP to FCA implemented around their European supply flows from 2020 to 2021. The case study that Forvia suggested was centered on evaluating the carbon dioxide emissions linked to the transport flows of a particular business operating in Europe. Its objectives were to identify the main sources of emissions and provide ways for reducing them. The following steps can be used to categorize it based on its process:

1. Data gathering: The first stage of this study required gathering information on the company's transportation flows for the year 2020, including the origin and destination of shipments, the modes of transportation employed, and the weights of the commodities transported. Each transportation flow was also highlighted during the data collection process according to the associated Incoterm.

Note: this data was collected through a combination of surveys, interviews, and analysis of company records

2. Emission analysis: the study assessed the carbon dioxide emissions linked to the company's transport flows using the data gathered. As the primary supply chain transportation choice for Forvia ESD, only emissions linked to road transportation have been assessed. Additionally, the emissions related to various supply chain phases, such as loading and unloading, have been examined.
3. Identification of emissions Hot-Spots: Our analysis was able to identify the primary sources of emissions by looking at the data and noticing patterns in the transportation movements. This has made it simpler to pinpoint the specific modes of transportation, points in the supply chain, or routes responsible for the majority of emissions.
4. Efforts to Reduce Emissions - Incoterm Switch from DAP to FCA: The study has suggested a method called "milk-run" to reduce the company's carbon footprint by grouping different DAP transportation flows into one groupage flow that uses only one transport (a single carrier selected by Forvia) to conduct all supplier collections and deliver them all at one scheduled date and time at Forvia's plant warehouse. This strategy is based on the analysis of all data and the identification of emissions hot-spots.
5. Monitoring and Implementation: The report also suggested a monitoring system to follow the adoption of this suggested course of action and gauge the amount of

emissions that are being cut. This made it possible for the business to monitor development and make the necessary modifications on schedule.

To do this, this initiative used eight different French suppliers who supply goods to one of Forvia ESD's sites in northern France, close to Lille. All of these suppliers were in charge of bringing items to the Forvia factory using the means of transportation that fell under their purview. Either dedicated trucks or groupage collections that they formed in order to distribute their goods to customers other than Forvia were acceptable.

Following the implementation of this project, each loading at these suppliers began to be completed by a groupage truck organized under Forvia responsibility; all 8 suppliers were responsible for preparing the goods in the time so that the full "milk-run" carriage would go to all of these eight warehouses and then proceed to deliver the goods directly at Forvia warehouse near Lille; in this way, all goods purchased to this supply base were collected under a single transportation.

It should be noted that each supplier determines its collection dates after accounting for the total transit time required by this transportation flow to ensure that the goods will arrive to Forvia's warehouse by the scheduled date when they will be required for manufacturing.

The case study's conclusions have been helpful for other supply chain flows across Forvia's many business groups as well as the transportation flows that were the subject of the investigation. These groups are all attempting to lower their transportation-related carbon emissions and contribute to a more sustainable future.

# 4. Results and discussion

## 4.1. PC&L case study

In order to discuss the results of this case study, a production coverage report has been prepared as a representation of logistic scenario – coverages for both scenarios will contemplate the planned deliveries and production report during weeks 40 and 41 from the year 2022.

First, let's go to the analysis of **Scenario 1**:

*Table 4 - Example of logisitic data representative of a small plastic part supplier, located in France*

| Material | Supplier name | Current stock | Safety stock | Min stock | Max stock | MOQ | Average daily consumption |
|---|---|---|---|---|---|---|---|
| Small plastic part | PLASTIQUES SAS | 2600 | 2000 | 750 | 5000 | 500 | 150 |

*Table 5 - Coverage analysis regarding our planned production at Forvia plant in France, considering both deliveries will be held accordingly and in due time*

| | WK40 | | | | | WK41 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MON | TUE | WED | THU | FRI | MON | TUE | WED | THU | FRI |
| Text | 03/11/22 | 04/11/22 | 05/11/22 | 06/11/22 | 07/11/22 | 10/11/22 | 11/11/22 | 12/11/22 | 13/11/22 | 14/11/22 |
| Requirements | 170 | 141 | 150 | 172 | 130 | 130 | 157 | 140 | 172 | 140 |
| Planned receipts | | | 500 | | | | | 500 | | |
| Projected stock | 2430 | 2289 | 2639 | 2467 | 2337 | 2207 | 2050 | 2410 | 2238 | 2098 |

above safety stock
below safety stock/above mininum stock
below minimum stock

By analyzing coverage scenario above, as well as for the planned deliveries of 500 plastic parts (corresponding to the MOQ that can be sent in 1 carton box) once per week, we are able to assess that this planning allows plant's production to have its safety stock secured – if an appropriate planning from logistics responsible is accordingly carried out between plant and supplier.

*Table 6 - Coverage analysis regarding our planned production at Forvia plant in France, considering one delivery will not be held accordingly and or i due time*

| | WK40 | | | | | WK41 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MON | TUE | WED | THU | FRI | MON | TUE | WED | THU | FRI |
| Text | 03/11/22 | 04/11/22 | 05/11/22 | 06/11/22 | 07/11/22 | 10/11/22 | 11/11/22 | 12/11/22 | 13/11/22 | 14/11/22 |
| Requirements | 170 | 141 | 150 | 172 | 130 | 130 | 157 | 140 | 172 | 140 |
| Planned receipts | | | 0 | | | | | 500 | | |
| Projected stock | 2430 | 2289 | 2139 | 1967 | 1837 | 1707 | 1550 | 1910 | 1738 | 1598 |

But in a scenario which goods are not delivered on 05/11/2022, and if plant does not have any feedback about when the missing parts will be delivered, its production will not have a considerate negative impact – stock level remains between safety stock parameters, in the worst-case scenario, until next planned delivery. Plant has time to react, in order to possibly plan next order for next week, while focusing on searching the missing parts that were scheduled to delivered on 05/11/2022.

Taking into account the non-obligation for customs clearance, low raw material cost, packaging non-returnable to supplier (1 carton box per week, cheap handling unit and easily degradable with time and usage) and, most importantly, the fact that the lack of visibility and tracking of the order goods does not necessarily cause a negative impact in production, we can assess that Forvia can establish a DAP incoterm agreement with this supplier: no need to support transportation costs, due to the lack of necessity to pay for visibility and goods ordered tracking; no need to support supplier regarding customs clearance negotiations; no need to negotiate parts' costs, due to their already established low price from the start.

Second, let's look at the results on **Scenario 2**:

*Table 7 - Example of logisitic data representative of a metallic frame supplier, located in Poland.*

| Material | Supplier Name | Current stock | Safety stock | Min stock | Max stock | MOQ | Average daily consumption |
|---|---|---|---|---|---|---|---|
| Metallic frame | Metal Pol S.P.Z.O.O | 320 | 225 | 125 | 400 | 20 | 150 |

*Table 8 - Coverage analysis regarding our planned production at Forvia plant in Slovakia, considering both deliveries will be held accordingly and in due time*

| | WK40 | | | | | WK41 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MON | TUE | WED | THU | FRI | MON | TUE | WED | THU | FRI |
| Text | 03/11/2022 | 04/11/2022 | 05/11/2022 | 06/11/2022 | 07/11/2022 | 10/11/2022 | 11/11/2022 | 12/11/2022 | 13/11/2022 | 14/11/2022 |
| Requirements | 157 | 137 | 175 | 171 | 124 | 153 | 147 | 123 | 134 | 184 |
| Planned receipts | 140 | 140 | 140 | 160 | 140 | 160 | 140 | 140 | 140 | 140 |
| Projected stock | 283 | 286 | 251 | 240 | 256 | 263 | 256 | 273 | 279 | 235 |

Coverage scenario (shown above) addresses a regular delivery of an average of around 8 pallets per day, for the specific reference at stake. Taking into account the cost per part (30€) and the big volume that each frame occupies within warehouse storage, it is important to have a stock a strict control over internal stock. This leads to the need of having a really tight just needed inventory (JNI) parametrization – which results in having regular deliveries – one per day, at 12h00 – so that the stock in transit can be accounted as if internal stock.

*Table 9 - Coverage analysis regarding our planned production at Forvia plant in Slovakia, considering one delivery will not be held accordingly and or i due time*

| | WK40 | | | | | WK41 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MON | TUE | WED | THU | FRI | MON | TUE | WED | THU | FRI |
| Text | 03/11/2022 | 04/11/2022 | 05/11/2022 | 06/11/2022 | 07/11/2022 | 10/11/2022 | 11/11/2022 | 12/11/2022 | 13/11/2022 | 14/11/2022 |
| Requirements | 157 | 137 | 175 | 171 | 124 | 153 | 147 | 123 | 134 | 184 |
| Planned receipts | 140 | 140 | 0 | 160 | 140 | 160 | 140 | 140 | 140 | 140 |
| Projected stock | 283 | 286 | 111 | 100 | 116 | 123 | 116 | 133 | 139 | 95 |

In a scenario where a delivery is missed on Wednesday 05/11/2022 and it is not possible to deliver the goods the same day, there is a notorious risk in production: plant will end the day under minimum stock, and have to move on to Thursday's 1st shift without having its production secure (taking into account that the next delivery would only be held after 12h00 that same day) - in a situation as the one described, the whole supply chain is at risk.

In order to react and prevent possible risks, it is important for Forvia plant to, first of all, receive a quick alert regarding the incident that resulted in the non-delivery of the ordered goods on Wednesday. Secondly, it is also important to have the possibility to monitor the goods position (in this case, this missing truck on way to the plant) every 2 hours, while being provided with a regularly updated ETA. This highlights the need to have a clear visibility over the supply chain and a tight control over the responsible carrier designated to transport the goods on a daily basis. In addition, Forvia production is depending on the deliveries scheduled on a regular basis, since part of its safety stock is constantly in transit from supplier to the plant; this means that internal stock is also being accounted, while not being physically in the plant - this requires a thorough control over the goods location at all times. Such activities become possible when the transport organization and coordination is under Forvia responsibility – which can be possible under an established FCA incoterm agreement between Forvia and its supplier.

Also, in terms of cost per ordered parts, Forvia can look for reducing the cost of each individual frame taking into account the fact that the company is already taking care of the transport organization and customs clearances processes – such negotiation aspects can provide beneficial savings on a long-term overview (for example, on the year's overall budget).

## 4.2. Carbon footprint case study

As mentioned before, this case study focused on the carbon footprint related to Forvia ESD transporation flows and the impact of changing the incoterm from DAP to FCA. In order to do so, it was monitored the carbon dioxide emissions associated from various DAP transportation flows that delivered goods to a Forvia plant in Northern France during the year of 2020, and then compared to the carbon dioxide emissions that resulted from the combination of all these flows into a single groupage ("milk-run") transport that delivered all the ordered goods at once and in the same date, at the referred plant.

Below, there is an overview of data retrieved from monitoring the transportations flow respective to the group of eight different suppliers selected for the purpose of this case study.

*Table 10 - Data on 2020 volumes of delivered pallets for each one of the eight suppliers.*

| | 2020 volumes (delivered by each supplier - DAP conditions) | | | |
|---|---|---|---|---|
| | Average number of pallets shipped | Monthly deliveries | Total flows (2020) | Total packages volume (2020) |
| Supplier A | 3 | 4 | 44 | 132 |
| Supplier B | 1 | 4 | 44 | 44 |
| Supplier C | 7 | 8 | 88 | 616 |
| Supplier D | 4 | 2 | 22 | 88 |
| Supplier E | 4 | 1 | 11 | 44 |
| Supplier F | 9 | 4 | 44 | 396 |
| Supplier G | 2 | 4 | 44 | 88 |
| Supplier H | 1 | 4 | 44 | 44 |

According to the data showed above, Forvia retrieved the following information:

1. Average number of pallets shipped by each supplier in each order from Forvia side.
2. Number of deliveries carried out by each supplier, on a monthly base.
3. Total transportation flows – supplier to Forvia plant – carried out by each supplier, during the year of 2020.
4. Total number of packages (pallets) delivered at Forvia plant by each supplier.

Therefore, it was concluded that during the year of 2020, all eight suppliers together delivered a total of 1452 pallets in Forvia plant, taking a total of 341 transports (supplier – Forvia).

Next, we have the information gathered after implementing a "milk-run" transportation flow (conducted by Forvia) in order to collect goods from all suppliers at once,

and consequently delivered them in the same date using only one transportation flow to do so.

*Table 11 - Data on 2021 volumes of delivered pallets for each one of the eight suppliers, under "milk-run" transportation flow (implemented by Forvia)*

| | 2021 volumes (collected under Forvia groupage - FCA conditions) | | | |
|---|---|---|---|---|
| | Average number of pallets collected | Monthly collections | Total flows (2021) | Total packages volume (2021) |
| Supplier A | 4 | 4 | 44 | 176 |
| Supplier B | 2 | 4 | | 88 |
| Supplier C | 15 | 4 | | 660 |
| Supplier D | 3 | 4 | | 132 |
| Supplier E | 1 | 4 | | 44 |
| Supplier F | 8 | 4 | | 352 |
| Supplier G | 3 | 4 | | 132 |
| Supplier H | 3 | 4 | | 132 |

As a result of monitoring 2021 results under a “milk-run” transportation flow, it is noted that 44 collections in total were capable of delivering a total of 1716 pallets to Forvia plant during the whole year.

*Table 12 - Results on the carbon footprint from 2020 and 2021 transportation flow analysis*

| Year | Shipments | Total pallets | CO2 (kg) | CO2/Pallet (kgCO2/HU) |
|---|---|---|---|---|
| 2020 | 341 | 1452 | 11891.88 | 8.19 |
| 2021 | 104 | 1716 | 10622.04 | 6.19 |
| **Variation** | -69.50% | **18.18%** | -10.68% | -24.42% |

By comparing the data retrieved during both years, it is possible to see at first that the number of shipments (or transports used to carry out this supply flow, in general) have decreased, in a representative way: it was estimated a reduction in needed transports of 69.5%. Also, it was noted that the total number of pallets transported in this specific flow has increased from 1452 to 1716, which represents an increase of 18.18%: the increase on pallets ordered to suppliers can be attributed to customer variations from 2020 to 2021; final customer needs and OEM production flows are constantly changing, therefore the total order need to each supplier – depending, obviously, on the raw-material purchased and the respective OEM project to be used – it is not linear. Therefore, it is possible to highlight reducing the volume of transports doesn´t necessarily mean that Forvia should expect to receive less material – in this case, have its needed goods in plant affected by transport conditions.

In addition, it was estimated that the reduction of transports used (341 to 104) has allowed to reduce the global carbon footprint associated to this supply flow (11891.9 to 10622. 04 kg) – at around 11%. Calculation of the CO2 footprint on each pallet is also, therefore, possible:

$$CO2\ per\ pallet\ (in\ kg\ per\ CO2\ per\ pallet) = \frac{Total\ CO2\ emissions\ volume}{Total\ of\ transported\ pallets}$$

For the year 2020, it was estimated a carbon footprint per pallet at about 8,19, whilst in 2021 this value reached a lesser value of 6,19 – a decrease of about 24.12%. This shows that, even though groupage conditions under FCA conditions require transports with higher volume (in order to carry a bigger load), the main factor that has impact on the carbon footprint is, in fact, the total volume of transports conducted from supplier to Forvia. Also, this means that under FCA rules, Forvia had an incentive to choose the most carbon-efficient mode of transport and to optimize the packaging and loading of the goods to minimize emissions.

Therefore, the results of this study show that changing the incoterm from DAP to FCA can lead to a reduction in the carbon footprint associated with transportation. By changing the transport agreements from DAP and FCA, besides all the benefits such as reducing the cost per purchased part or having more visibility over the supply chain, Forvia could also thrive in having a supply chain based on contributing for a more sustainable environment and, consequently, reduced the carbon footprint impact associated to its activities – nevertheless, further reductions can be achieved by focusing on the optimization of the logistics chain and the choice of transportation mode.

# 5. Conclusion

The FCA incoterm has been found to be the best choice for the company's supply chain operations based on the study that has been done. The choice of FCA can give the business the adaptability and control it needs to improve logistics and lessen its carbon footprint.

According to the study, the FCA incoterm gives the organization the freedom to select the mode, carrier, and route that best suits their requirements. For the business to lower its carbon footprint and optimize supply chain operations, this level of control over logistics is crucial. Furthermore, the FCA incoterm enables the business to benefit from cost-cutting alternatives including cargo consolidation and the use of intermodal transportation.

The study also discovered that the FCA incoterm offers cost-saving potential for the supplier because it frees them up from having to plan and pay for transportation as well as limits their liability for any damage to the items that occurs during delivery.

It is crucial to remember that the DAP incoterm, which stands for "Delivered at Place," might also be a good choice in some circumstances or for some suppliers. The DAP incoterm gives the supplier responsibility for transportation and all associated costs, giving the business a more economical choice.

The study concludes that the organization may have the flexibility and control it needs to improve logistics and lessen its carbon footprint by adopting the FCA incoterm as the principal term for its supply chain operations. Additionally, since it lowers their liability and shipping expenses, it is advantageous for the suppliers. However, given that DAP incoterms may also be more appropriate in some circumstances pertaining to the sector itself, it makes sense that the company should assess the acceptability of each incoterm on an individual basis and carefully analyze the advantages and disadvantages of each alternative before making a selection. In the end, the business should make an effort to strike the ideal balance between affordability, logistics control and compliance, and environmental sustainability.

# Bibliography

[1] World of Work Report 2009: The Global Jobs Crisis and Beyond. International Institute for Labor Studies – Geneva: ILO, 2009

[2] Ambe, I. M., & Badenhorst-Weiss, J. A. (2011). An automotive supply chain model for a demand-driven environment. Journal of Transport and Supply Chain Management, 5(1), 1-22.

[3] Rutherford, James & Haidekker, Sandy & Matheson, Fleur & Hicks, Andrew. (2021). Modelled effects of channel orientation and tree canopy shape on average shade in streams. New Zealand Journal of Marine and Freshwater Research. 57. 1-25. 10.1080/00288330.2021.1950193.

[4] Afsharipour, Afshari & Sahaf, (2007). E-Procurement in Automotive Supply Chain of Iran. Social Science and Business Administration Programmes, p. 37

[5] Binder, Mario, Peter Gust, and Ben Clegg. "The Importance of Collaborative Frontloading in Automotive Supply Networks." Journal of Manufacturing Technology Management. Emerald Publishing Limited, March 14, 2008. https://doi.org/10.1108/17410380810853759.

[6] Cox, A., and Daniel Chicksand. "Aligning Brand and Supply Chain Strategies." ResearchGate, January 1, 2006. https://www.researchgate.net/publication/272495246_Aligning_Brand_and_Supply_Chain_Strategies.

[7] Ambe, Marcus. "Determining Supply Chain Practices and Strategies of Light Vehicle Manufacturers in South Africa." (PDF) Determining supply chain practices and strategies of light vehicle manufacturers in South Africa | Marcus Ambe - Academia.edu, n.d. https://www.academia.edu/70703920/Determining_supply_chain_practices_and_strategies_of_light_vehicle_manufacturers_in_South_Africa.

[8] R.Chase & F. R. Jacobs (2006), 'Operation Management for Competitive Advantage10th edition, Tata McGraw Hill, New Delhi, pp. 24-31.

[9] Sunil Chopra & Peter Meindl (2005), 'Supply Chain Management', Pearson Education, New Delhi.

[10] Davis, Jonathan, and John Vogt. 2021. "Hidden Supply Chain Risk and Incoterms®: Analysis and Mitigation Strategies." Journal of Risk and Financial Management. MDPI AG

[11] Alexandridis, George, Manolis G. Kavussanos, Chi Y. Kim, Dimitris A. Tsouknidis, and Ilias D. Visvikis. 2018. A survey of shipping finance research: Setting the future research agenda. Transportation Research Part E: Logistics and Transportation Review 115: 164–212

[12] Mukhtar, Arwa, Awanis Romli, Mansoor Abdullateef, and Hael Al-bashiri. 2019. "Environmental Risks in Supply Chain: Recommendations and Directions for Future Research." IOP Conference Series: Materials Science and Engineering.

[13] Zucatto LC, Veiga CHA, Evangelisa M.LS. Estudo comparativo entre as abordagens de supply chain management e de green supply chain management na perspectiva da sustentabilidade.

[14] Pusavec F, Krajnik P, Kopac J. Transitioning to sustainable production – Part I: application on machining technologies. J Clean Prod 2010; 18:174-84.

[15] Seuring S, Sarkis J, Müller M, Rao P. Sustainability and supply chain management – an introduction to special issue. J Clean Prod 2008; 16:1545-51.

[16] Fransoo, Jan C., Hans-Otto Günther, and Werner Jammernegg. 2013. "Environmental Sustainability in Supply Chains." Flexible Services and Manufacturing Journal. Springer Science and Business Media LLC.

[17] Gooley, T. (2000) Incoterms 2000: What the Changes Mean to You. Logistics Management and Distribution Report 39, p. 49

[18] Lane, S. (2012). Incoterms 2010: What you really need to know. Business Credit, 114(8), 1-2.

[19] Jimenez, G. (1998) Incoterms Questions and Answers. ICC Publishing.166 pages. Paris

[20] Chevalier, D. (2000) Incoterms 2000 : Tous les mécanismes ». MOCI. Hors série. 50 pages. Paris

[21] The Importance of Incoterms | RTS International. "The Importance of Incoterms | RTS International," March 23, 2020. https://www.rtsinternational.com/article/importance-incoterms

[22] International Trade Administration | Trade.gov. "Know Your Incoterms," n.d. https://www.trade.gov/know-your-incoterms.

[23] Incoterms® | International Chamber of Commerce | Delmar. "Incoterms® | International Chamber of Commerce | Delmar," n.d. https://www.delmarcargo.com/incoterms

[24] International Chamber of Commerce. ICC Uniform Customs and Practice for Documentary Credits, 2007 revision. 2006. Paris, France: ICC Services Publications Department. ISBN 928421257X.

[25] Barrios, Katherine. “A Full Breakdown Of Incoterms (International Commercial Terms).” A Full Breakdown Of Incoterms (International Commercial Terms), n.d. https://www.xeneta.com/blog/incoterms.

[26] ICC - International Chamber of Commerce. “Incoterms® Rules History - ICC - International Chamber of Commerce,” February 15, 2023. https://iccwbo.org/business-solutions/incoterms-rules/incoterms-rules-history/

[27] Montezuma, Johnatas. “Incoterms.” FCA – Free Carrier (Place of Delivery) - Incoterms 2020 - Incoterms, n.d. https://internationalcommercialterms.guru/incoterms-fca/

[28] Ramberg J., Incoterms 2010, Eur. JL Reform 13 (2011) 380

[29] Vogt, John, and Jonathan Davis. 2020. “The State of Incoterm® Research.” Transportation Journal. The Pennsylvania State University Press

[30] HEEJUN KIM. (2021). The Incoterms 2020 revision : Unsolved problems on FCA Rules

[31] KIM, Jin-Hwan. 2022. “The Comparative Study of Incoterms 2020 and 2010 in International Physical Distribution.” Journal of Distribution Science 20 (4). Korea Distribution Science Association: 101–10

[32] Montezuma, Johnatas. “Incoterms.” FCA – Free Carrier (Place of Delivery) - Incoterms 2020 - Incoterms, n.d. https://internationalcommercialterms.guru/incoterms-fca/

[33] Incoterms Explained. “Free Carrier - Incoterms Explained,” n.d. https://www.incotermsexplained.com/the-incoterms-rules/the-eleven-rules-in-brief/free-carrier/

[34] Montezuma, Johnatas. “Incoterms.” DAP – Delivery at (Place of Destination) - Incoterms 2020 - Incoterms, n.d. https://internationalcommercialterms.guru/incoterms-dap/

[35] Broding, Horst & Fartasch, Manigé. (2020). Automotive Industry. 10.1007/978-3-319-68617-2_134.

[36] Zhan X, Chen R (2006). Forecast-driven or customer-order-driven? An empirical analysis of the Chinese automotive industry, Int. J. Operations Prod. Manage., 26(6): 668-688

[37] Christopher M, Rutherford C (2004). Creating supply chain resilience through agile six sigma. Critical Eye, June-August, 24-28

[38] Gunasekaran A, Lai KH, Cheng TC (2008). Responsive supply chain: A competitive strategy in a networked economy. Int. J. Manage. Sci., 36: 549-564

[39] Hugo WMJ, Badenhorst-Weiss JA, Van Biljon EHB (2004). Supply chain management: logistics in perspective. 3rd edition, Pretoria: Van Schaik.

[40] IBM (2009). The Smarter Supply Chain of the Future; Automotive Industry Edition.

[41] LFB, LFB. "AUTOMOTIVE INDUSTRY OVERVIEW." (PDF) AUTOMOTIVE INDUSTRY OVERVIEW | LFB LFB - Academia.edu, n.d. https://www.academia.edu/36183492/AUTOMOTIVE_INDUSTRY_OVERVIEW

[42] Ambe, Intaher & Badenhorst-Weiss, Johanna. (2011). An automotive supply chain model for a demand-driven environment. Journal of Transport and Supply Chain Management. 5. 10.4102/jtscm.v5i1.18.

[43] Journal, Jabian. "Digital Is Driving Waves of Auto Industry Innovation." The Jabian Journal, August 17, 2017. https://journal.jabian.com/digital-is-driving-waves-of-auto-industry-innovation/

[44] Zhang, X. & Chen, R. 2006. Forecast-driven or customer-order-driven? An empirical analysis of the Chinese automotive industry. International Journal of Operations and Production Management. 26(6):668-88.

[45] Holweg, M., Disney, S.M., Hines, P. & Naim, M.M. 2005. Towards responsive vehicle supply: a simulation-based investigation into automotive scheduling systems. Journal of Operations Management. 32(5):507-30.

[46] Tang D, Qian X (2008). Product lifecycle management for automotive development focusing on supplier integration, Computers in industry, 59: 288-295.

[47] Benko C, McFarlan W (2004). Metamorphosis in the auto industry. Strategy and Leadership, 31 (4): 4-8.

[48] Shapiro JF (2007). Modeling the supply chain, 2nd edition, Thormson, USA.

[49] Ambe, Intaher & Badenhorst-Weiss, Johanna. (2010). Strategic supply chain framework for the automotive industry. African Journal of Business Management. 4. 2110-2120.

[50] Sahay BS, Gutpta FNJ, Mohan R (2006). Managing supply chains for competitiveness: The Indian scenario. Supply chain management: Int. J., 11(1): 15-24.

[51] Christopher M (2005). Logistics and supply chain management: Creating value-added networks. Harlow, England: Prentice Hall.

[52] SCM (Supply chain management) – SI Essentials. "SCM (Supply Chain Management)," June 6, 2015. https://siessentials.wordpress.com/2015/06/06/scm-supply-chain-management/

[53] Sherer, S. 2005. From supply-chain management to value network advocacy: implications for e-supply chains. Supply Chain Management: an International Journal. 10(2):77-83.

[54] Jayadevappa, Ravishankar, and Sumedha Chhatre. 2000. "International Trade and Environmental Quality: A Survey." Ecological Economics. Elsevier BV

[55] Stojanovi´c, Đ.; Iveti´c, J.; Veli˘ckovi´c, M. Assessment of International Trade-Related Transport CO2 Emissions—A Logistics Responsibility Perspective. Sustainability 2021, 13, 1138

[56] Bechmann, Ralf, and Martin Scherk. "Globalization in the Automotive Industry–Impact and Trends." Globalization in the Automotive Industry–Impact and Trends | SpringerLink, January 1, 2009. https://doi.org/10.1007/978-3-642-01178-8_14

[57] Population - Worldometer. "Population - Worldometer," n.d. https://www.worldometers.info/population/

[58] Bloomberg, Center for Automotive Research (2008).

[59] Mercer, F. (2004). Future Automotive Industry Structure (FAST) 2015.

[60] The Geography of Transport Systems | The spatial organization of transportation and mobility. "Global Greenhouse Gas Emissions by the Transportation Sector | The Geography of Transport Systems," August 3, 2019. https://transportgeography.org/contents/chapter4/transportation-and-environment/greenhouse-gas-emissions-transportation/

[61] Cristea, A.; Hummels, D.; Puzzello, L.; Avetisyan, M. Trade and the greenhouse gas emissions from international freight transport. J. Environ. Econ. Manag. 2013, 65, 153–173

[62] OECD/ITF. The Carbon Footprint of Global Trade: Tackling Emissions from International Freight Transport; OECD/ITF: Paris, France, 2015; Available online: https://www.itf-oecd.org/sites/default/files/docs/cop-pdf-06.pdf

[63] Van Veen-Groot, D.; Nijkamp, P. Globalization, transport and the environment: New perspectives for ecological economics. Ecol Econ. 1999, 31, 331–346

[64] Davydenko, I.; Ehrler, V.; de Ree, D.; Lewis, A.; Tavasszy, L. Towards a global CO2 calculation standard for supply chains: Suggestions for methodological improvements. Transp. Res. Part. D Transp. Environ. 2014, 32, 362–372

[65] ICC. Incoterms® 2010: ICC Rules for the Use of Domestic and International Trade Terms; International Chamber of Commerce Publishing S.A: Paris, France, 2010

[66] Cook, T. Mastering the Business of Global Trade: Negotiating Competitive Advantage Contractual Best Practices, Incoterms®, and Leveraging Supply Chain Options; CRC Press: Boca Raton, FL, USA, 2014

[67] Van den Berg, R.; De Langen, P.W. Environmental sustainability in container transport: The attitudes of shippers and forwarders. Int. J. Logist. Res. Appl. 2016, 20, 146–162

[68] Kumar, S. Logistics routing flexibility and lower freight costs through use of Incoterms. Transp. J. 2010, 49, 48–56.

[69] Vogt, J.; Davis, J. The State of Incoterm® Research. Transp. J. 2020, 59, 304–324.

[70] Hien, Nicolas, Gilbert Laporte, and Jacques Roy. "Business Environment Factors, Incoterms Selection and Export Performance." OSCM Journal, December 1, 2014. https://doi.org/http://doi.org/10.31387/oscm040017.

[71] Juthathip;AMCHANG SURARAKSA, Nutcharin; Chompoonut;SAWATWONG. "Decision-Making on Incoterms 2020 of Automotive Parts Manufacturers in Thailand -The Journal of Asian Finance, Economics and Business." Decision-Making on Incoterms 2020 of Automotive Parts Manufacturers in Thailand -The Journal of Asian Finance, Economics and Business, January 1, 2020. https://doi.org/10.13106/jafeb.2020.vol7.no10.461

[72] Arvis, J. F., Duval, Y., Shepherd, B., Utoktham, C., & Raj, A. (2016). Trade costs in the developing world: 1996-2010. World Trade Review, 15(3), 451–474. https://doi.org/10.1017/ S147474561500052X

[73] De, P. (2007). Impact of trade costs on trade: Empirical evidence from Asian countries. Trade Facilitation beyond the Multilateral Trade Negotiations: Regional Practices, Customs Valuation and Other Emerging Issues – A Study by the AsiaPacific Research and Training Network on Trade, 27, 281–307.

[74] Chamsuk, W. (2018). Factor affecting to supply chain risk in Thai automotive industry. Business Review, 10(1), 123–142. https://www.tci-thaijo.org/index.php/bahcuojs/article/view/162260

[75] Sawangpaew, K. (2012). The study on the possibility in changing an agreement sale of goods between CIP (Incoterms 2000) and DDP (Incoterms 2010): A case study of

advanced information technology public Co. Ltd. Journal of Politics, Administration and Law, 4(1), 287–340.

[76] An, H. J., & Kim, W. K. (2019). A case study on the influence factors of financial performance of Korean automotive parts cooperation companies through research hypothesis. Journal of Asian Finance, Economics and Business, 6(3), 327-337

[77] Thailand Board of Investment. (2017). Thailand's automotive industry: The next-generation. https://www.boi.go.th/index.php?page=business_opportunities_detail&topic_id=117517

[78] Levy, D. (1995). "International Sourcing and Supply Chain Stability," Journal of International Business Studies, Vol. 26, No. 2, pp. 343-360

[79] Smith, J. (2008). "Exploiting the Global Supply Chain," World Trade, May, Vol. 21, No. 5, pp. 32-36

[80] Murray, M. (2000). International Commercial Terms. Accessed 22 June 2010.

[81] Yang, Jung-Ho. “A Study on the Reasonable Choice and Utilization of Incoterms 2020 Rules from the Perspective of Logistics and Supply Chain Management - 학지사・교보문고 스콜라.” kyobobook, n.d. https://doi.org/10.35611/jkt.2021.25.1.152.

[82] Incoterms 101 – What are Incoterms and why are they so important? – Transglory. “Incoterms 101 – What Are Incoterms and Why Are They so Important? – Transglory,” n.d. https://www.transglory.com/en/what-are-incoterms-international-trade/

[83] Yaakub, S., Szu, L. Y., Arbak, S., & Halim, N. A. (2018). INCOTERMS selection factors and its effect on export performance. Journal of Advance Research in Business, Marketing, and Supply Chain Management, 2(1), 9-18.

[84] Trang, T. Van, & Do, Q. H. (2020). Critical success factors of TQM implementation in Vietnamese supporting industries. Journal of Asian Finance, Economics and Business, 7(7), 391-401

[85] Saaty, T. L. (2008). Decision making with the analytic hierarchy process. International Journal of Services Sciences, 1(1), 83.