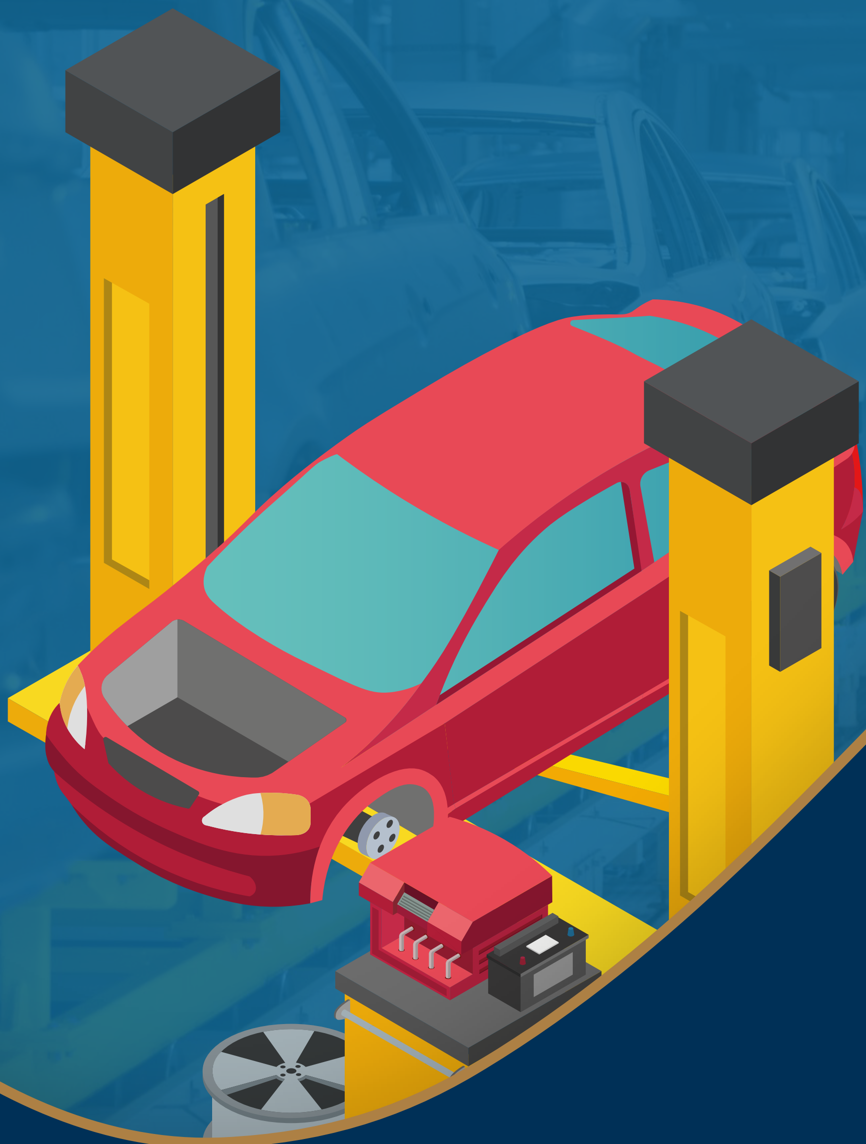
Georgia Tech Panama
Logistics Innovation & Research Center

Regional Hub for the
Automotive Industry



Driving Efficiency: The Supply Chain for Vehicles

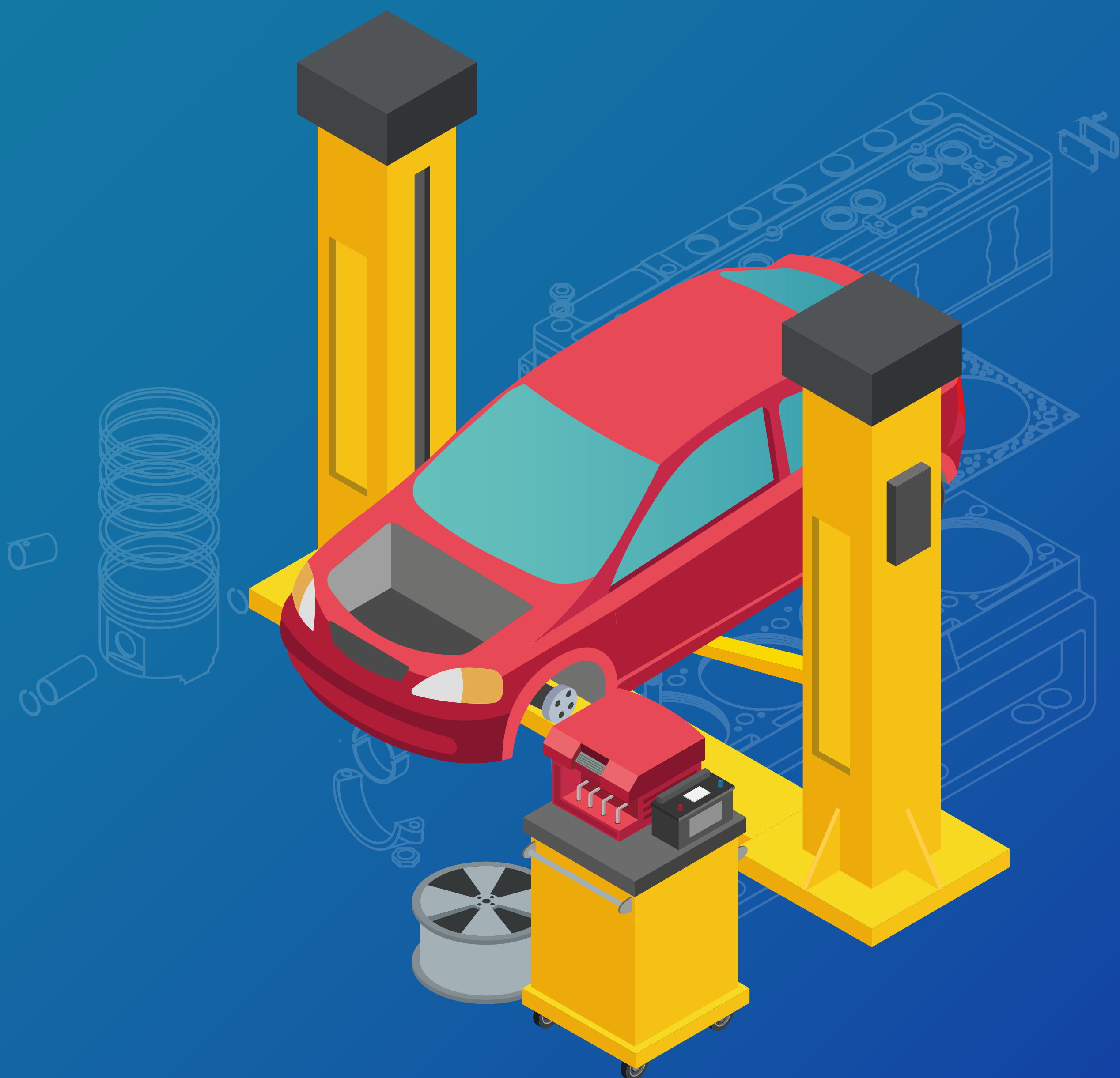
Prepared by: Angela Agudelo

Georgia Tech Panama Logistics Innovation and Research Center

August, 2025

www.gatech.pa | logistics.gatech.pa

Driving Efficiency: The Supply Chain for Vehicles



Georgia Tech Panama
Logistics Innovation & Research Center

Regional Hub for the Automotive Industry

Overview

The automotive industry contributes to the global economy by generating millions of direct and indirect jobs within a highly globalized supply chain. Through the installation of production plants in different countries and the generation of demand for components, technology, supplies, auto parts, fuel, among others. This industry fosters economic development in large regions by promoting innovation, technological progress and GDP growth in many countries. [1][2][3]

In the same way, the automotive industry influences other sectors of the economy through the transport of people and goods, increasing trade and international competitiveness, primarily in the logistics sector. As a key player, it provides the means of transport to facilitate the delivery of supplies, merchandise and products.
The automotive industry is an example of a resilient industry, recovering and innovating quickly after economic crises and disruptions that may occur, such as the economic crisis of 2008 and the recent COVID-19 pandemic. Its influential nature in other industries and sectors requires continuous innovation to maintain competitiveness and immediate response to disruptions.

To achieve this, industry leaders invest in research and development (R+D), to enhance production efficiency and sustainability. An example of this is the development of electric and hybrid vehicles, and their batteries. Despite current risks and barriers that their supply chain currently has, it is estimated that their production will increase over the years due to the need to reduce CO2 emissions, the increase in electric mobility to mitigate climate change, and the trends of new consumers prioritizing environmental consciousness. [3][4][5]

According to data from the OICA (International Organization of Motor Vehicle Manufacturers), in 2023 vehicle production closed with 68.02 million passenger vehicles, 21.44 million light commercial vehicles, 3.77 million heavy trucks and 310 thousand units of buses and coaches. The top five producing countries are China with 30.16 million, USA with 10.61, Japan with 8.99 million, India with 5.85 million and South Korea with 4.24 million units produced. [6]

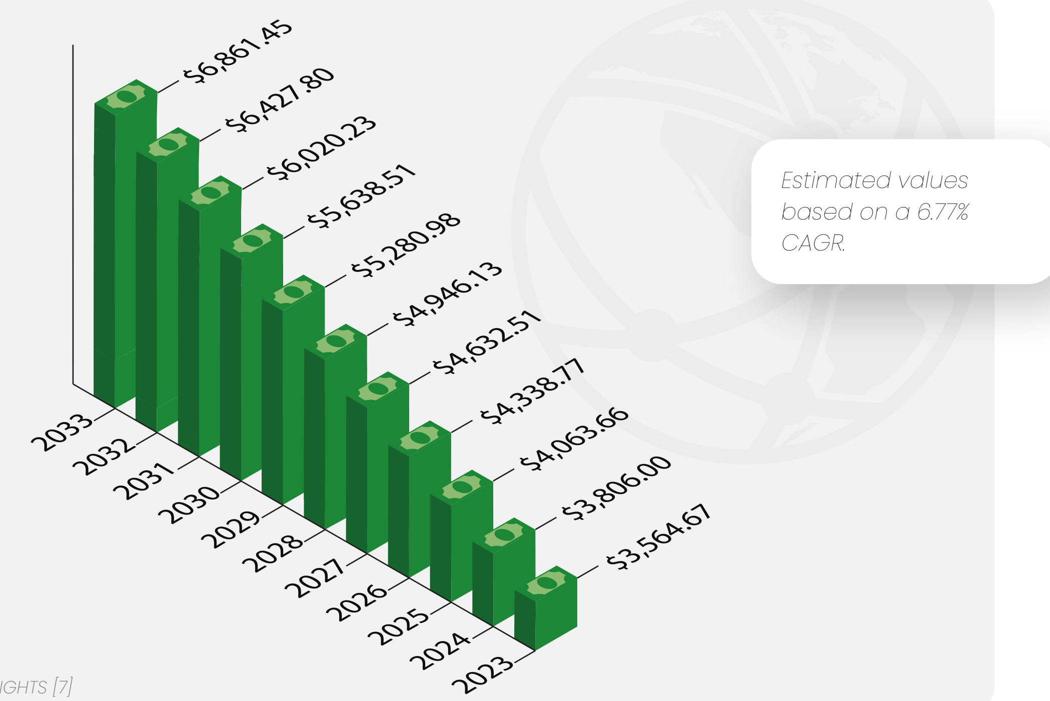
In the context of the American continent, the top producing countries were: USA in first place with the aforementioned figures, Mexico in second with 4 million units, Brazil in third with 2.32 million units, Canada fourth with 1.55 million units, Argentina fifth with 610,725 units and Colombia sixth with 34,700 units. [6]

Units in Argentina only include cars and light commercial vehicles.

On the other hand, the world market was valued at USD 3,564.67 billion in 2023, and an increase to USD 6,861.45 billion is estimated by 2033, with a CAGR of 6.77%. [7]

Global vehicle sales exceeded 92 million units in 2023. The percentage of sales was recorded as follows: 51% in Asia/Pacific, representing 47.12 million units, 21% in North America, which means 19.40 million units, 19% in Europe, equivalent to 17.55 million units, 4% in South America, equal to 3.69 million units and 5% in other developing economies, with 4.62 million units remaining [8].

Expected growth of the global automotive industry market (in billions of USD)



Source: SPHERICAL INSIGHTS [7]

Classification of Industry Products

In the automotive industry, product sorting makes it possible to improve both the supply chain and production processes. This classification facilitates efficient inventory management and better integration of the distinct parts and components that make up vehicles.

The most well-known classification of vehicles by consumers is by type of fuel or the engine they use. If you wish to learn more about engines, please refer to the information provided in the first document. Accor-ding to this classification, vehicles can be categorized as follows:

- **Internal combustion vehicles:** use petrol or diesel engines.
- **Electric vehicles:** powered by electric motors or batteries.
- **Hybrid vehicles:** combine internal combustion engine and electric motor.
- **Hydrogen vehicles:** use hydrogen fuel cells. They are typically classified as electric vehicles due to their similar mode of operation.

Meanwhile the **large vehicle-producing groups** in the automotive industry **classify** their product portfolio **according to production lines**, distinguishing between light and heavy vehicles.

Light vehicles

Are those designed to carry a small amount of passengers or load. They tend to have small dimensions and have just four wheels. It subcategories are passenger cars and light commercial vehicles (or light duty trucks) [9][10][11][12][13]:

Passenger cars

Those used to transport passengers, and do not include more than 8 seats; they have low capacity of cargo. Among these are the different vehicles by body type

- **Sedan.** Vehicles with capacity for five people. They are characterized by being built in three blocks: engine, vehicle interior and trunk.

- **Hatchback.** Unlike the sedan, this one has the interior space of the vehicle connected to the trunk, which gives the opportunity for more storage space if desired. The trunk lid opens completely either upwards or to the sides. This design allows the trunk to be counted as an additional, fifth door in the vehicle's specifications.

- **Coupé.** They are two-door vehicles. It can have one or two rows of seats and seeks to provide an elegant design by having a sloping roof. There are some four-door models known as "Quadruple Coupé".

- **Station Wagon.** Its structure is similar to a hatchback in terms of connection between the interior space and the trunk. The difference is that the stations have a lower ground clearance and a longer length.

- **Convertibles.** They are vehicles with a convertible roof, that is, it can be folded or disassembled. Another characteristic is that it can be soft or hard. The soft is a characteristic black waterproof material, like vinyl or canvas, and the hard can be plastic or steel.

- **Sporty.** By definition, sporty cars are two-seater convertibles with an aerodynamic appearance. They have agile maneuverability, excellent acceleration, and power.

Light commercial vehicles.

Those are the vehicles used for the transport of products and people. They have lower weight than heavy vehicles. This subcategory includes

- **Light duty trucks.** They are utilized for the transport of goods. This subcategory includes:
  - Pick Up. Characterized by its open cargo area at the rear, known as the hopper. They share almost the same body structure with SUVs.
  - Panel Van. Vehicles with a closed chassis, designed mainly for the transport of goods in urban areas.

- **SUVs.** Characterized by their easy manufacture through the single-body structure. In Sport Utility Vehicles (SUVs), the chassis is generally based on a light truck, a pickup truck or an all-terrain vehicle. It is characterized by all-terrain wheels, high-strength suspension, four-wheel drive, and higher ground clearance than other vehicles.

- **Crossover.** Similar to SUVs in terms of a single manufacturing body. In contrast, crossovers have a lightweight structure. The chassis is based on the conventional platform of a vehicle, closer to the ground and conventional tires.

- **Minivan.** Also known as a multipurpose vehicle. It offers three rows of seats, capacity of five to seven seats, reasonable ground clearance, but not as much as SUVs. In the large versions, it has sliding doors for passengers and the rear door has hinges at the top.

- **Van.** Categorized as a commercial vehicle due to its load capacity for both goods and passengers. They have a capacity of up to 15 seats for passenger transport. Some have 6 wheels so they can be considered heavy vehicles, depending on its capacity.

Heavy vehicles

Are those designed to carry a large amount of passengers and load. They have bigger dimensions and have more than six wheels. The main characteristic of heavy vehicles is their weight greater than 3.5 tons. These are subclassified into: buses, trucks and specialized equipment [9][10][11]:

Buses

Vehicles used for the transport of more than nine passengers, and a load capacity of more than seven tons, these are classified according to the maximum passenger capacity [14]:

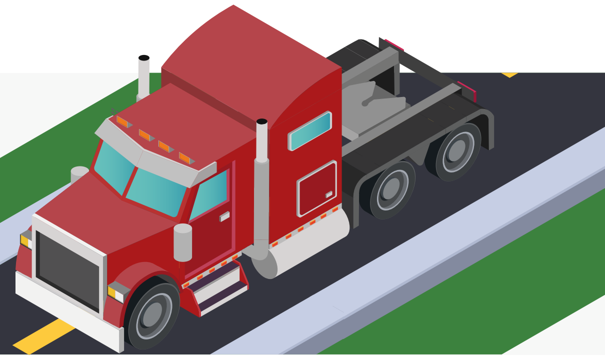
- **Minibus:** has a capacity of up to 16 seats.

- **Medium bus:** they have a capacity of between 25 and 40 passengers.

- **Large bus:** they have a capacity of between 50 and 70 seats, with ample interior space. They can have up to 2 floors which increases their seating capacity.

Trucks

Vehicles used for the transport of cargo [15][16]:

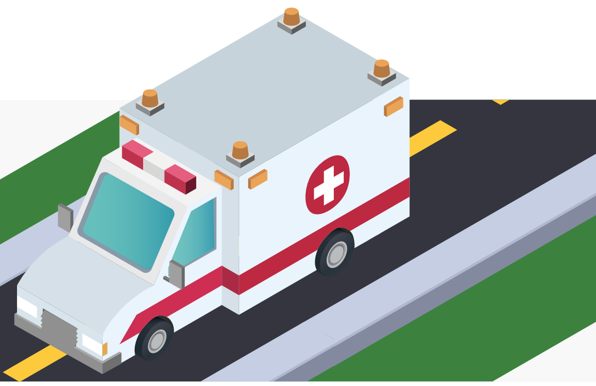


- **Medium truck:** it has a load capacity of between two and thirteen tons. It has a weight greater than seven tons, a chassis of 6 tires or more, a length of 3.5 to 6.5 meters and a height of 2 to 2.5 meters.

- **Heavy trucks:** with a load capacity of more than thirteen tons. They have a length of more than seven meters, for example: unit truck, trailer truck, tanker truck, cage, vehicle carrier, articulated truck, among others.

Specialized equipment

Those designed and used for activities in specific sectors, such as the construction, agricultural and livestock sector, and vehicles designed under specifications such as ambulances and fire trucks.



- **Specialized equipment for construction:** such as excavator, backhoe, dredgers, dragline, slips, paver, compactor, dump trucks, tractors. [17][18]

- **Specialized equipment for agriculture:** tractors, seeders, combines, hoppers, andforagers. [19]

- **Ambulances:** they are produced under specifications depending on their type and function to be performed. Ambulances can be light, such as basic transfer ambulances, and heavy such as: the mobile ICU, overly complex transfer ambulance, rescue truck, among others. [20]

- **Fire trucks:** These can be pumping trucks, airport vehicles, forestry trucks, hazardous materials units, among others. [21]

Looking forward: sustainability

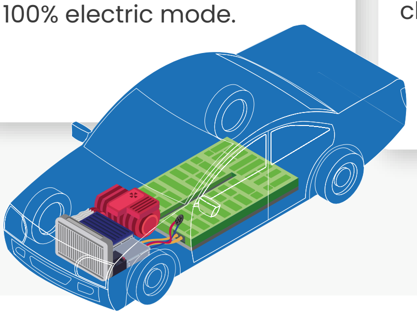
Faced with new consumer demand and government requirements, to be a more sustainable industry and mitigate climate change, the automotive industry is seeking to reinvent itself.
It has developed electric and hybrid vehicles in recent years, adopting new technologies to reduce the carbon footprint and increase energy efficiency.
These vehicles ensure the competitiveness and future of the industry, generating new employment opportunities, specialized supply chains, and niche markets. [22][23]

Electric vehicles (Care those that have a battery that stores electricity, which powered one or more motors. These vehicles are classified according to the way they obtain electrical energy [25][26].

BEV or Battery Electric Vehicle.
They are connected to the electricity grid to get the energy that feeds the battery. They have a long battery life in 100% electric mode.

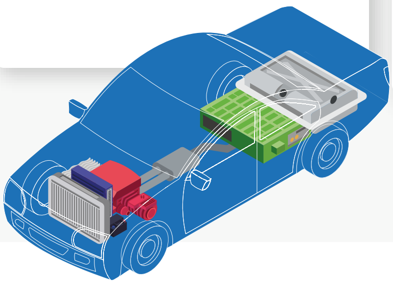
E-REV or Extended Range Electric Vehicle.
The battery is recharged by connecting the car to the power grid, but a small heat engine powers it if the charge drops too low.

FCEV or Fuel Cell Electric Vehicle.
Hydrogen is the energy source, it is supplied like gasoline, in combustion vehicles. The fuel cell transforms hydrogen into electrical energy. This is stored in a battery and moves the electric motor. [24]



Hybrid vehicles are powered by an internal combustion engine and one or more electric motors, which are powered by the energy stored in the batteries. These can be [25][26]:

MHEVs or Mild Hybrid Electric Vehicles (also known as micro-hybrids).
These are vehicles with a small electric motor and battery, which optimizes the use and fuel economy.



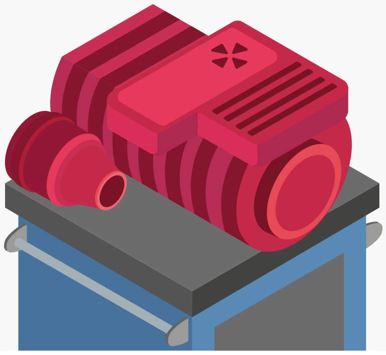
HEV or Hybrid Electric Vehicle.
Vehicles with a combustion engine and electric motor powered by batteries. They use the energy released during the braking of the vehicle to recharge the batteries.

PHEV or Plug-in Hybrid Electric Vehicle.
They can be connected to external power sources to recharge the batteries that power the electric motor. The combustion engine is activated when charge levels decrease, or higher speeds are needed.

The characteristic parts of electric and hybrid vehicles, distinguishing them from traditional combustion engine vehicles, include [27][28]:

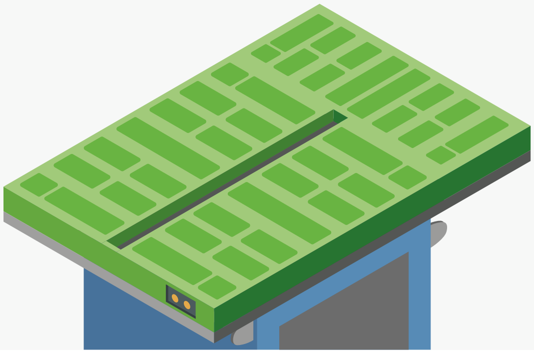
Electric motor/generator

It is responsible for converting the electrical energy from the grid into movement to drive the wheels. They are the most common in electric vehicles due to their ease of use and easy installation. There are two types: synchronous (permanent magnets, switched reluctance) and asynchronous or induction.



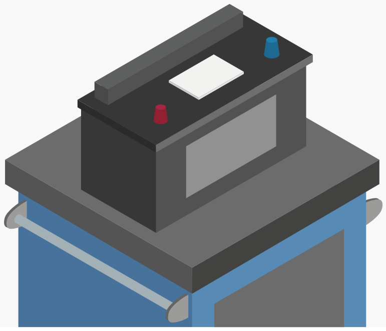
Traction battery

It stores the electrical energy supplied from the grid.
The energy is used to move the vehicle.
The storage capacity of batteries is measured in kWh, and their size determines the range and weight of the vehicle.



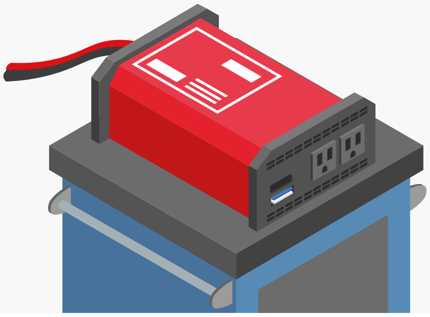
Auxiliary Battery

This is the 12V battery commonly used in internal combustion vehicles and hybrid vehicles.
This supplies electricity to the auxiliary systems and the vehicle before the traction battery is activated.



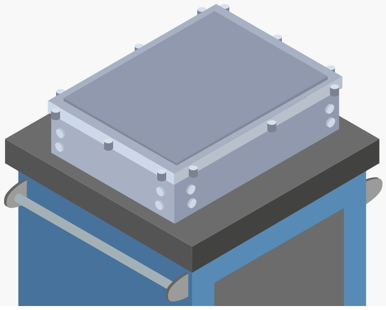
Current converter

Also known as an inverter. This part is responsible for converting the lower voltage DC energy of the traction battery into higher voltage DC energy for the electric motor.



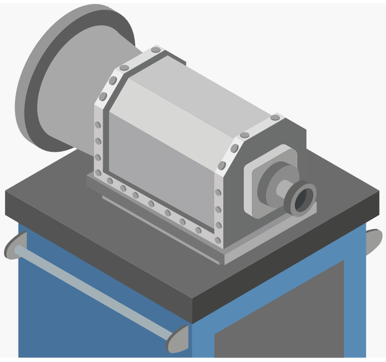
On-board charger

This element converts the incoming alternating current into the direct current required by batteries, from a domestic electrical outlet.



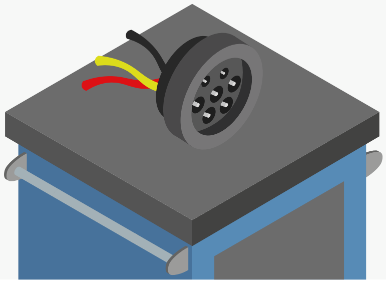
Transmission

Most electric motors tend to use all the torque instantly, so they only have one gear.



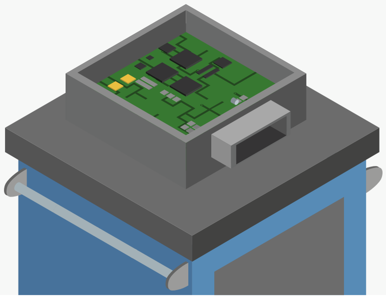
Charging socket

This part allows the vehicle to be connected to a charging point.
This can use single-phase alternating current, three-phase direct current, depending on the type of charger.



Electronic module

It receives the driver's commands, processes them and controls the speed, torque and direction of the engine. It also controls the flow of energy between the battery pack and the motor.



The electric vehicles market has grown significantly, reaching nearly 14 million units and representing 18% of all cars sold in 2023 - a notable growth of 3.5 million units higher compared to 2022. However, there are still adoption challenges in many countries, such as the lack of charging infrastructure, high raw material costs, anxiety about autonomy and lack of consumer education. [22]

To address these barriers, numerous countries have already submitted action plans until 2035. These plans include constructing more charging facilities, financial incentives, improving vehicle range and improving battery technology. Successfully implementing these initiatives requires coordinated efforts and partnerships between the public sector and private enterprises. Together, these efforts aim to accelerate the transition to sustainable mobility, reduce greenhouse gas emissions, and align with global environmental goals. [22][29]

Player Movements

Over the years, players have made alliances, mergers, purchases and sales aimed at maintaining competitiveness and the life of brands. These strategic movements have reduced the number of OEM (Original Equipment Manufacturing) groups.

The acquisition of KIA by Hyundai in 1998 is one example of those transformations. Hyundai aimed to expand its market, reduce costs, and increase competitiveness across a broader product range. This acquisition allowed Hyundai to produce more cars annually and gain economies of scope by integrating KIA's strengths in commercial vehicles and minivans into its product lineup. [30]

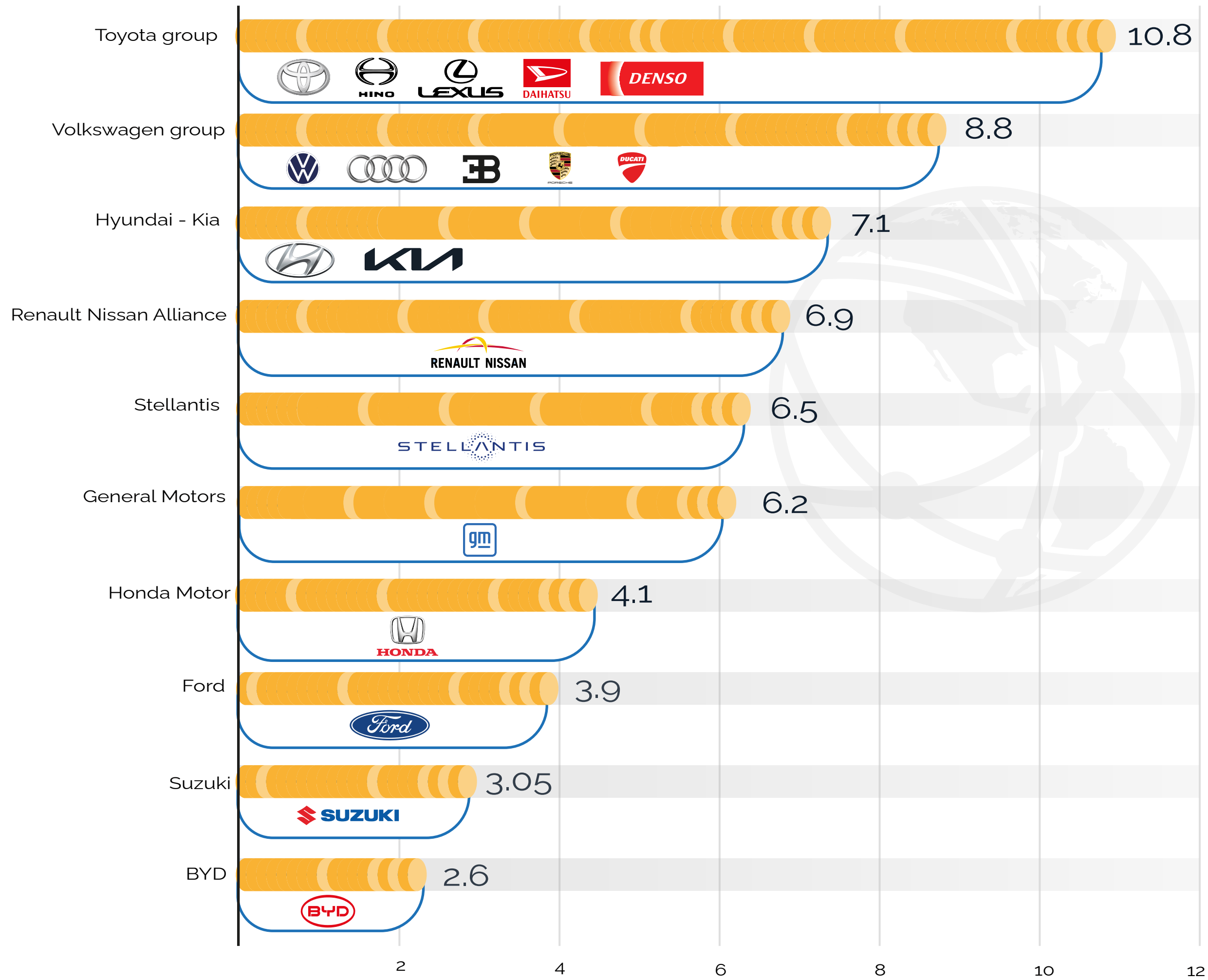
In 1999, the formation of the Renault-Nissan-Mitsubishi alliance and its renewal in 2023 with a new cooperative business model to improve competitiveness and profitability. They focused on standardization and efficient vehicle production, sharing investments in platforms and technologies. Each member became a reference for their key regions, leveraging their geographical and technological strengths [31]:

- Nissan is focusing on China, North America and Japan.
- Renault is leading in Europe, Russia, South America and North Africa.
- Mitsubishi in ASEAN (Association of Southeast Asian Nations) and Oceania.

Other notable milestones include Tata Motors' acquisition of Jaguar and Land Rover in 2008; [32] the 2010 purchase of Volvo by Chinese automaker Geely; and Geely's subsequent acquisition of a 9.7% stake in Daimler AG in 2018. [33] Daimler AG —later rebranded as Mercedes-Benz Group AG in 2022— retained ownership of the Mercedes-Benz automobile brand following the spin-off of its truck division into Daimler Truck Holding AG. [34][35]

In January 2021, the merger between the Fiat Chrysler Automobiles (FCA) and PSA Groupe groups gave rise to STELLANTIS, a global automotive powerhouse representing a diverse portfolio of brands, including Abarth, Alfa Romeo, Chrysler, Citroën, Dodge, DS Automobiles, Fiat, Jeep, Lancia, Maserati, Opel, Peugeot, Ram and Vauxhall. [36]
These alliances and restructuring efforts reflect the industry's ongoing pursuit of adaptability, operational efficiency, and innovation in an ever-evolving global market.

Top automakers by sales in 2023 (in millions of units)



Source: graph obtained from Statista [37]

By 2023, the main OEM producer groups in the industry with the largest share of the market were: Toyota Group (10.8 million units), Volkswagen Group (8.8 million units) and Hyundai-KIA (7.1 million units). [37]
As groups that have already launched electric, hybrid or hydrogen vehicles on the market or emerged purely in the production of these vehicles, we can mention: Tesla, BYD, BAIC Motor, Chery, General Motors, Ford, KARMA AUTOMOTIVE, FISKER, LUCID MOTORS, RIVIAN AUTOMOTIVE, CANOO, LORDSTOWN MOTORS, Volkswagen, MERCEDES-BENZ, BMW, PORSCHE, RENAULT, STELLANTIS, TATA MOTORS, TOYOTA, NISSAN, HONDA, SUZUKI, MAZDA, MITSUBISHI, SUBARU, ISUZU, HYUNDAI, among other. [38]

Strategic Alliances

To improve production processes and reduce costs, several leading automotive players have entered into strategic collaborations. These collaborations aim to leverage synergies, enhance technological advancements, and achieve better economies of scale. Some notable partnerships include:

- **Toyota and Subaru (2005 onward).** In 2005, Toyota and Subaru closed a commercial collaboration agreement, gradually expanding their collaboration in various areas, such as development, production and sales. This partnership led to the commercialization of the Toyota 86 and Subaru BRZ in 2012 and the Subaru Crosstrek Hybrid, a plug-in hybrid electric vehicle (PHEV) in the United States. [39]

  In 2019 they agreed to jointly develop a specific platform for battery electric vehicles (BEVs), aimed at medium and large passenger cars. This agreement combines Subaru's all-wheel-drive technologies and Toyota's electrification technologies. [39] In addition, Subaru plans to release three more electric SUVs by the end of 2026, all developed in collaboration with Toyota. [40]

- **Toyota and BMW (2011 onward).** In 2011, Toyota Motor Corporation and BMW signed agreements to establish medium-term cooperation in environmental technology, developing fuel cell systems and sports vehicles. Recently, both companies strengthened their collaboration to move towards a hydrogen society and achieve carbon neutrality. Their joint efforts include developing a third-generation hydrogen fuel cell system, with BMW planning to launch its first mass-produced fuel cell electric vehicle (FCEV) in 2028.

  This collaboration aims to reduce costs, create synergies and expand demand for commercial vehicles and fuel cell passenger cars. Both companies are also focusing on hydrogen infrastructure and distribution to ensure stable supply. [41]

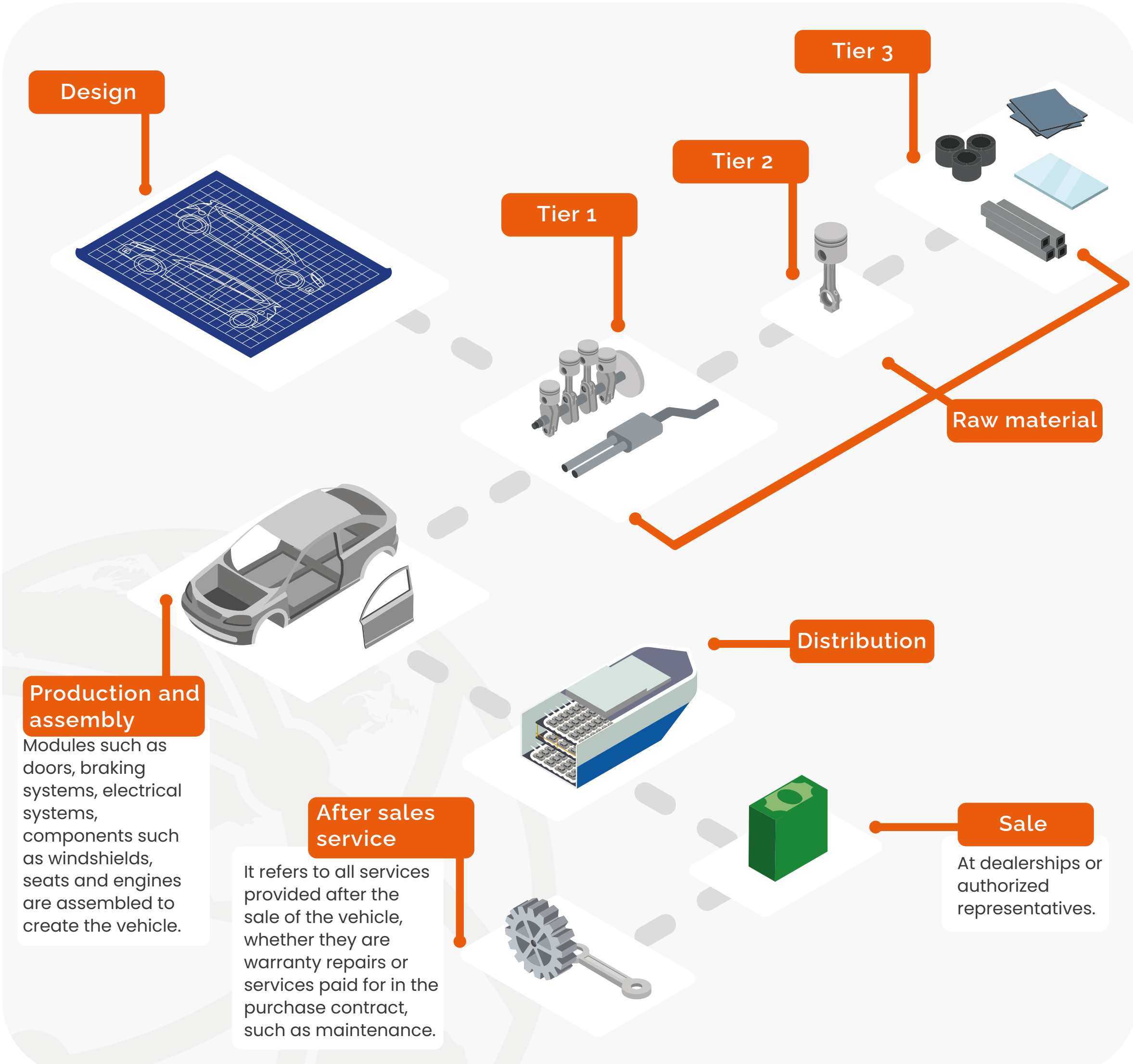
- **Toyota and Stellantis (2012 onward).** In 2012, the relationship between Toyota and Stellantis began to jointly produce vehicles. The most recent outcome is the Toyota Proace Max, a battery-electric van launched on the European market in July 2024. These vans are manufactured at the Stellantis' plant in Gliwice, Poland, while the diesel variants are manufactured in Atessa, Italy [42].

- **Ford and Volkswagen (2020 onward).** In 2020, Ford and Volkswagen signed agreements to jointly develop commercial, electric and self-driving vehicles. As of 2022, the result of this agreement was the production by Ford of a midsize pick-up truck, sold by Volkswagen as Amarok.

  In 2023, Ford began production of an electric vehicle based on Volkswagen's electric drive platform, both brands worked independently on autonomous vehicles using Argo AI technology. The continuation of this alliance is expected to achieve significant efficiencies and wider global distribution of electric and commercial vehicles. [43]

- **General Motors and Hyundai Motor Company (September 2024).** In September 2024, General Motors and Hyundai Motor Company signed an agreement to explore future collaboration in areas such as joint product development, manufacturing, and clean energy technology. Both companies seek to improve efficiency and increase competitiveness by collaborating, reducing costs, and accelerating the availability of a wider range of vehicles and technologies to customers.
  Potential projects include the joint development and production of passenger and commercial vehicles, internal combustion engines, and clean, electric, and hydrogen technologies. They will also review opportunities for the combined procurement of raw materials for batteries, steel, and other materials. [44]

Through Vehicle's Supply Chain



The automotive supply chain is characterized by its complexity and the high level of coordination that must exist between its suppliers, manufacturers and distributors to ensure the efficiency and quality of production. This is made up of multiple levels of suppliers, direct and indirect, due to the supply chain of parts and components, see the first document. Third-level indirect suppliers are those who supply the raw material to second-level suppliers, who are responsible for transforming it into intermediate products, and first-level suppliers or direct suppliers are those in charge of supplying parts and components directly to vehicle manufacturing groups. [45][46]

1. Design and Development

The design of the vehicles of the industry is not only to foresee the trends and tastes of consumers in the future to ensure an attractive aesthetic, but the design also involves thinking about the functionality of the vehicle and offering both aesthetic and functional appeal, maximizing energy savings, fuel savings and minimizing CO_2 emissions. That is why in this link, the shape and characteristics of both, the vehicle and the parts that must compose it, are developed to ensure its functionality and quality. [47][48]
The steps in the vehicle design process are:

1) Understand the trends and needs of the future and the context in which the vehicle will be driven. Inspiration can come from various sources: architectural trends, fashion, nature, prototypes, earlier projects, among others.

2) Create exterior and interior sketches of the vehicle. For this, it must be considered the function that it will fulfill and how its design will affect the way it will be driven. The following must be contemplated :

- Defined requirements, such as rigidity and resistance.
- Technical conditions, such as wheelbase.
- Capacity of the vehicle.
- Safety requirements.
- The aerodynamics of the car.
  That is, the way in which the air will behave around it.
  The behavior of the air influences the resistance to advance, fuel consumption, autonomy, stability at high speeds, among others. Aerodynamic studies are carried out to ensure that the air around the vehicle behaves properly at this stage; and the characteristics, finishes and materials to be used, depend on this in order to guarantee an ideal weight. [49]

3) Engineers develop the vehicle parts based on the design and the intended functionality of the vehicle. Finally, the design and the developed parts are integrated to create 3D designs to start the inspection process of them, to then make life-size prototypes of the vehicle and ensure the functionality, quality and safety tests of each of its parts.

Participants in this link are the OEM groups and the design companies, materials laboratories and other interested companies that they hire.

2. Procurement of raw materials

This link integrates all the suppliers of the different components, systems and raw materials, such as iron sheets for the manufacture of the vehicle body. The raw material can come from the same country in which the production is taking place or from other countries and/or regions.

The relationships of manufacturing groups for vehicle manufacturing are mostly only with first-tier suppliers. However, **the literature links the participants of the auto parts supply chain as the vertical links of this horizontal link**, due to the crucial role they play and the importance attached to them as quality products. On the other hand, in order to become part of its supply chain, the suppliers of the main suppliers must also adhere to the norms and standards set by the OEM manufacturer group.

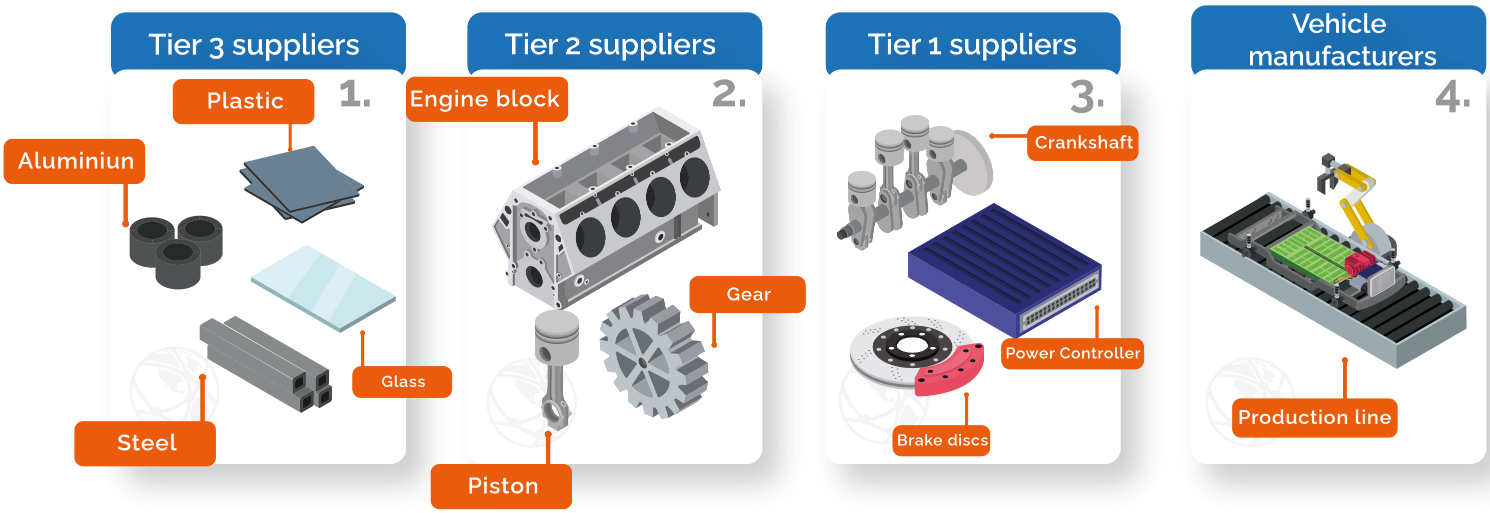
As described in the first document on the auto parts supply chain, the vertical structure of the supply chain operates as follows:

1) The suppliers of raw materials, such as: steel, aluminum, plastics, glass and rubber are tier 3 suppliers.

2) These materials are then delivered to tier 2 suppliers, who transform them into intermediate products, such as: engine case, suspension, component, and similar parts.

3) These intermediate products are subsequently supplied to tier 1 suppliers, who assemble them into modules such as brake systems, engines, powertrain, among others.

4) Finally, these modules are delivered to vehicle manufacturers, who incorporate them into the main production line.



It is worth noting that the supply chain involves a vast network of suppliers, and certain components —such as engines, bodywork and batteries— are produced by OEM groups in their own factories. These factories may focus exclusively on specific components or include full vehicle production within their operations [45][46].
Some examples of suppliers are: BorgWarner, Eaton Corporation, Federal mogul, Weber GmbH & Co. KG, Tenneco, Aisin Corporation, ACDelco.

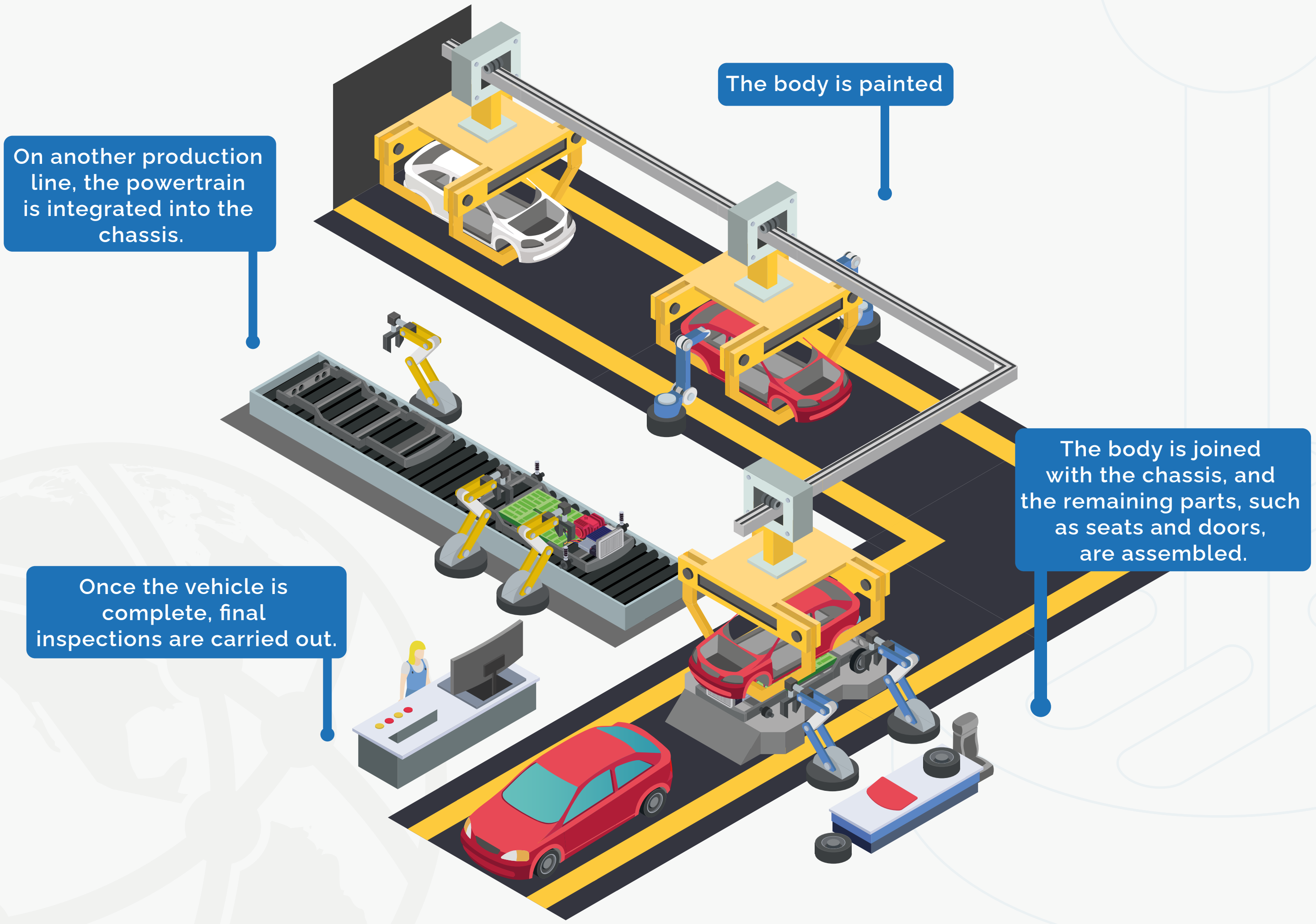
3. Production

OEM groups have factories in several countries worldwide, with each facility specializing in the production of specific models. In these factories, production is conducted on assembly lines that operate under lean production principles and just-in-time (JIT) manufacturing systems. Production occurs under two types of demand:

- **Pull demand**, which refers to vehicles produced in response to specific customer orders.

- **Push demand**, where vehicles are produced to create demand in the market.

In bodywork production factories, the process begins with the reception of steel sheets, which then go through a press to be stamped into the desired shape. These stamped parts are then welded to create the external structure of the vehicle. In contrast, in assembly-only factories, the parts arrive separately, and the production process begins with welding the parts to assemble the external body.



After having the body assembled, it is transferred to an assembly line where it will be painted and then joined with another line for assembly. Simultaneously, on a separate assembly line, the process begins with the reception of the chassis that are incorporated into the production line. On this line, other parts are progressively assembled, such as suspension, axles, transmission and engine. As the assembly line continues, the body is joined with the interior components like seats, dashboard, and steering wheel, as well as its exterior components, including welding the roof and doors, hood, bumpers, fenders. Once the vehicle is fully assembled, the final inspection tests are carried out.

Quality inspections are conducted throughout the entire production process, starting with the reception of parts and continuing along the assembly line to verify proper assembly and performance.
Tests include alignment check, resistance evaluation and electrical tests. Once the vehicles are fully assembled, it undergoes aesthetic evaluations and dynamic tests to certify that it is suitable for sale and consumption.
Each station included in the assembly line works in a JIT manner, which means that the part to be assembled is created or ordered only when it is needed. This avoids the improper use of space, allowing clean production without waste or extra inventory costs. [50]

4. Distribution

Once the production of the vehicles is completed, the units are transferred to dealerships or distribution centers, from where they are dispatched to different points of sale, whether national or international.

The distribution process involves multiple transportation modes, including rail, sea and road. **Rail transport** is usually used for long-distance shipments, allowing the transport of large volumes at competitive costs. **Road transport**, on the other hand, is used for shorter distances and for final delivery to dealers, through the use of specialized trucks such as car carriers or nanny trucks. For international distribution, **maritime transport** is the preferred option with the use of specialized vessels such as Ro-Ro (Roll-on/Roll-off) ships, which are designed to efficiently load and unload wheeled cargo. [50]

Notable providers of the Ro-Ro transportation services include Wallenius Wilhelmsen, NMT Shipping, Grimaldi Euromed, NYK line, among others.

In unusual cases, the **air transport** is used, relying on cargo planes. This mode distribution is the fastest, however it is little used due to its high cost and cargo limitations [51].

5. Sale

Motor vehicle manufacturers sell their vehicles through authorized dealers or authorized representatives of the brands, who act as intermediaries between the manufacturer groups and the consumer. These dealers and groups handle marketing and selling vehicles to consumers, as well as offering financing options and trade-in services. Authorized groups and brand representatives must ensure that vehicles meet market expectations and promote the brand experience as a differentiator from the competition by providing vehicle information, offering test drives, and easing financing options. [53]

6. After sale services

After-sales services involve the provision of maintenance and repair services, as well as the supply of spare parts. Automakers typically have a network of authorized service centers to provide these services to customers.

In recent years, there has been an increasing emphasis on providing excellent customer service and building strong customer relationships. This has led to the development of innovative after-sales service programs, such as extended warranties, roadside assistance, and loyalty programs [53].

Supply Chain Challenges

The supply chain of the automotive industry faces different challenges, primarily driven by globalization, environmental regulations and the transition to electric vehicles (EVs). Traditional supply chains are designed for just-in-time operations, making them vulnerable to disruptions such as port congestions and border closures. In addition, trade tensions between economic powers —such as the United States and China— have prompted companies to diversify their suppliers, increasing the complexity of inventory management and quality control. These conditions have led to additional costs and delays in delivering vehicles to consumers. [54][55]

With the aim of mitigating climate change and achieving net zero emissions, the new government regulations that apply to the reduction of CO2 emissions and decarbonization have significantly increased the costs across supply chains. These regulations demand closer cooperation between all participants in the chain, and the automotive industry in general. For combustion vehicles, this means improving traditional supply chains to meet stricter standards of energy efficiency and sustainability. For electric vehicles, it means managing the recycling of batteries and improving their processes. According to the World Economic Forum, the circular economy is a key strategy to reduce waste generated by end-of-life batteries, while minimizing the need for new raw materials. [55][56]

On a positive note, regulatory frameworks such as the EU's Green Deal and the U.S. Inflation Reduction Act, promote the transition to net zero through incentives and infrastructure investments. [57][58]

Transition to electric vehicles

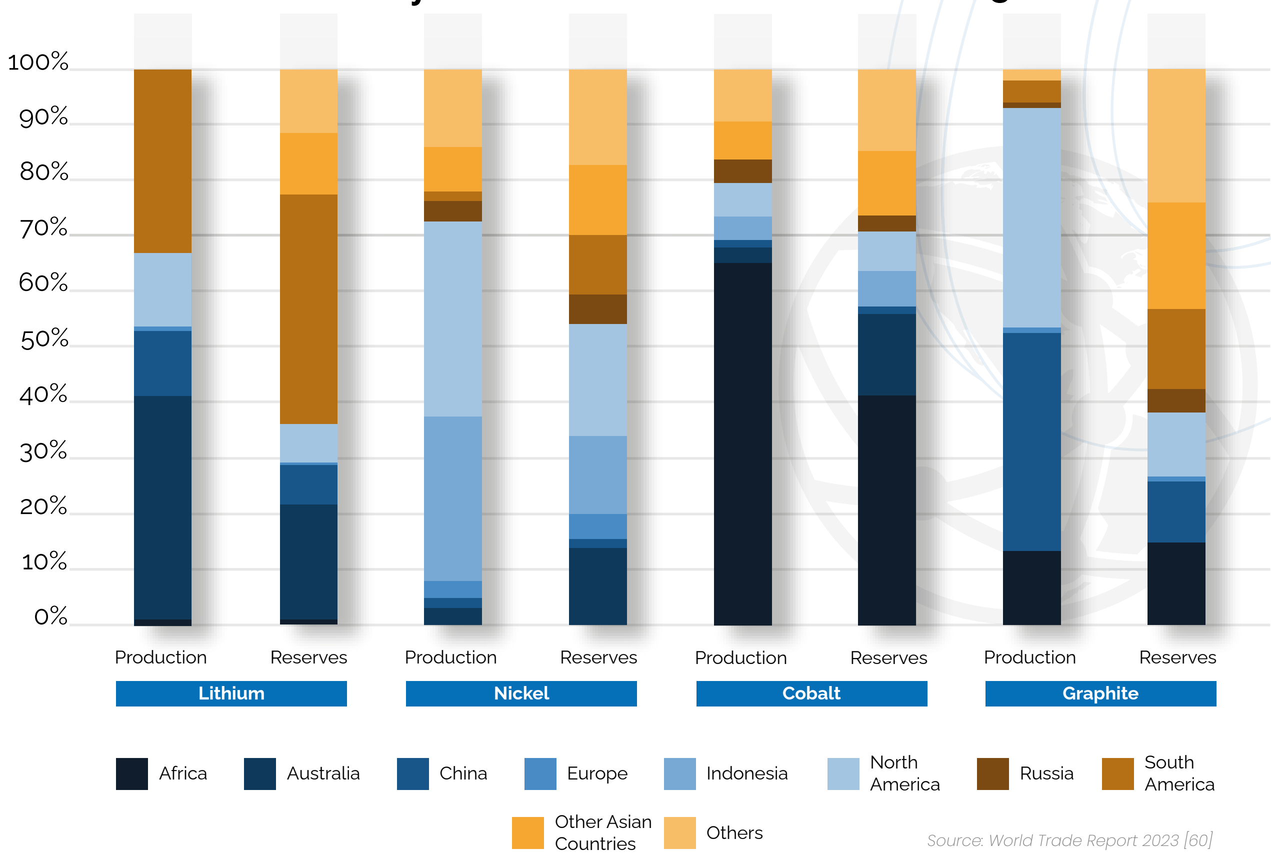
The transition to EVs depends on the supply of essential materials such as lithium, cobalt, and nickel —used in the manufacture of batteries. Projected demand for these minerals has outstripped current production capacity, especially in key markets such as the United States and Europe. For instance, a study by the International Council on Clean Transportation (ICCT) estimates that by 2032 it will be necessary to triple lithium production to meet EV (electrical vehicle) growth. At the same time, fluctuations in the prices of these raw materials affect manufacturing costs, delaying price parity between EVs and traditional vehicles. [53][54]

The battery supply chain faces issues related to the ethical and sustainable extraction of materials. The lack of regulation in some cobalt-producing regions, such as the Democratic Republic of Congo, raises environmental and social concerns. This has encouraged manufacturers to look for alternative materials, and increase investment in recycling to reduce dependence on new extractions. While some regions, like the European Unions, enforce stringent regulations, global collaboration is necessary to establish sustainable practices across all producing nations [22][55].

Battery technology supply chain

By 2022, battery supply chains were concentrated in China, which produced three-quarters of the total lithium-ion batteries and had high cathode (70%) and anode (85%) production capacities. [59]
The opportunity to diversify the battery chain by obtaining the raw material in other countries was presented as an alternative, however, many nickel and cobalt reserves are in countries with geopolitical tensions and export restrictions [60].

EV battery metal reserves outside China (2023)



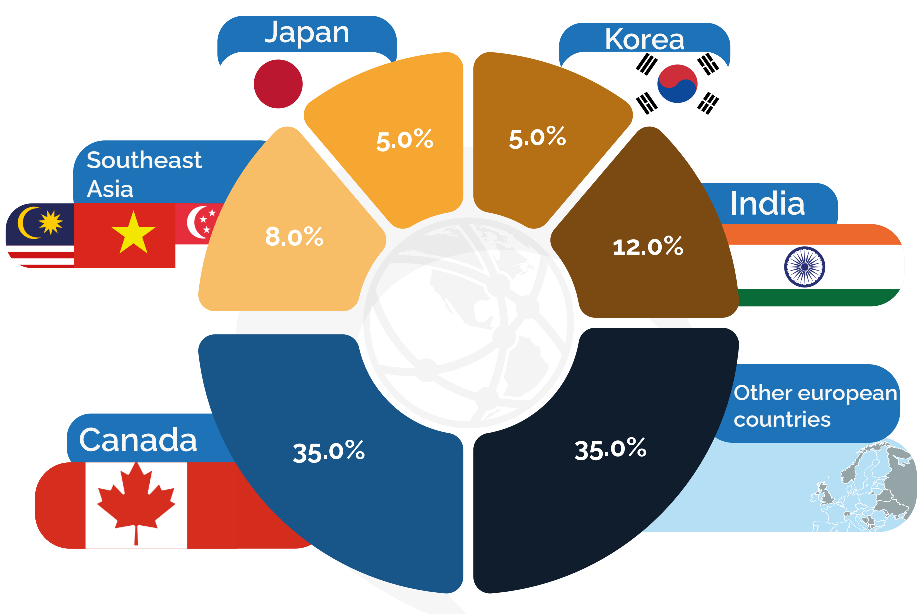
Source: World Trade Report 2023 [60]

While lithium-ion batteries dominate the market, alternatives like NCM (nickel, cobalt and manganese) batteries have emerged. They use less lithium than the common batteries, however, manganese has limitations in extraction and export like other materials, increasing costs.

There are studies for the next generation of cathodes that substitute common cathodes which utilize cobalt and nickel. This next generation utilizes innovative higher capacity cathodes based on abundant and inexpensive elements such as sulfur, iron, manganese, or even air-based cathodes. Although their composition is based on more abundant materials, they are far from commercialization due to their poor life cycle. [61]

At present, battery production occurs in different countries, however, China maintains its leadership by being the only country that currently produces twice what it demands. In contrast, countries of the European Union and the United States have almost or just enough production capacity for their demand. Both regions have plans to increase their production capacity with the construction of more manufacturing plants, expected to be operational by 2030. [22]

Estimated Growth of the heavy duty vehicles autoparts industry worldwide



According to the Global EV Outlook 2024 from the International Energy Agency (IEA), South America presents significant potential for growth, but no major production capacity has been announced for the region by 2030 [22].

Semiconductor dependency

The automotive industry relies significantly on semiconductors for functions like connectivity, driver assistance systems, and energy management in EVs and internal combustion vehicles (ICVs). However, the automotive industry's reliance on semiconductors has revealed vulnerabilities in the supply chain, particularly in copper production and chip manufacturing. The COVID-19 pandemic and geopolitical tensions have reduced chip production capacity, leading to disruptions that could last until 2025. This problem has forced manufacturers to reduce vehicle production, prioritizing models with higher margins. According to the Association of Global Automobile Manufacturers, this phenomenon highlights the need to diversify semiconductor production and encourage investment in local plants. [62][70]

Supply Chain Opportunities

Circular Economy: Recycling EV components

Recycling old EV batteries and using the reclaimed minerals to build new ones not only makes financial sense but also promotes environmental sustainability. As EV manufacturers face an uncertain future regarding access to critical minerals like lithium and cobalt, recycling and repurposing these materials is becoming a top priority. The Inflation Reduction Act (IRA) encourages this approach by offering incentives for battery materials recycled within the U.S. to qualify for domestic-content benefits, regardless of their origin. [68]
According to a report by the Basel Convention Regional Center, Latin America and the Caribbean generate an increasing amount of electronic waste, including end-of-life batteries. Developing a regional framework for recycling these batteries can reduce dependency on

virgin raw materials, minimize environmental impacts, and create new economic opportunities. Countries like Mexico and Brazil are exploring initiatives to integrate recycling practices into their supply chains, but more widespread efforts are necessary to establish a cohesive regional strategy. [66][67]

Latin America's Strategic Role in the Global Battery Supply Chain

Latin America is strategically poised to become a critical player in the global battery supply chain, leveraging its vast natural resources, particularly lithium and copper, essential components for batteries, charging infrastructure and semiconductor production.

The so-called Lithium Triangle —comprising Bolivia, Argentina, and Chile— produces approximately a third of the global lithium supply. Additionally, Chile and Peru together produce nearly 40% of the global copper supply. This wealth of resources positions Latin America as a potential powerhouse in the global battery supply chain, provided it can overcome certain barriers and take advantage of existing opportunities. [63]

One of the key opportunities lies in the upstream segment of the supply chain, particularly lithium extraction and processing. The region’s vast reserves, combined with increasing global investments, present a compelling case for enhancing production capabilities. Countries in the Lithium Triangle have already attracted significant interest from international corporations aiming to secure raw materials for battery manufacturing. However, the development of this industry requires robust policies that ensure sustainable extraction methods and equitable distribution of benefits to local communities. [63][64][65]

Midstream activities, such as refining and chemical processing, remain underdeveloped in Latin America. Currently, most of the extracted lithium is exported as a raw material, missing the opportunity to add value within the region. Establishing refining facilities and fostering partnerships with technology providers could enable Latin America to move up the value chain. For example, Chile's Economic Development Agency (CORFO) has already initiated efforts to promote local lithium processing through incentives and partnerships with global firms, while Peru has sought to modernize its copper value chain through similar initiatives. [64][65]

Latin America's strategic geographic position also offers logistical advantages for integrating into the global supply chain. Its proximity to the United States, one of the largest EV markets, and its established trade agreements with North America and Europe can facilitate the export of both raw materials and processed components. However, realizing these opportunities is contingent on addressing several challenges. Political instability, regulatory uncertainties, and insufficient investment in research and development (R&D) pose significant barriers to the region's competitiveness. Governments must prioritize creating a stable investment climate, streamlining regulations, and fostering public-private collaborations to spur innovation in battery technologies.

Closing

The automotive industry is undergoing significant transformations to enhance competitiveness and address emerging challenges. Companies are focusing on innovation sustainability and adapting to global trends, including:

- The search for emerging markets, with the growth of some economies such as India, Indonesia, Turkey, Nigeria, the Philippines and Mexico. This presents significant opportunities for market growth and risk diversification.

- Strengthening local production capacities, encouraged by government policies that seek to reduce dependence on foreign markets.

- Investment in recycling technology, by recovering valuable materials from end-of-life batteries, decreasing the need for new extractions.

- The digitalization of the chain through the implementation of new technologies in manufacturing and inside the vehicles. The use of them can improve the traceability of materials and the ability to predict interruptions. [22][54] Some trends in digitalization are:

- The Internet of Things (IoT) allows real-time monitoring, promoting the autonomy of vehicles and connectivity between them, improving the visibility of each link.

- Through artificial intelligence, demand can be predicted

- With the use of blockchain, the authenticity of parts is guaranteed and quality control is reinforced throughout the production line.

- Redesign of the chain with flexible and customized production through modularity and micro factories, and new forms of consumption, such as shared mobility . [4][42][69]

In this context, Panama emerges as a strategic partner, providing a robust logistics infrastructure that caters to the automotive industry's needs. The country provides a multimodal transport system, ports with connectivity with more than 148 ports in 50 countries on a weekly basis, with facilities and experience in handling Ro-Ro vessels, and equipped with cold handling capabilities and digital tracking, essential for sensitive components such as electric vehicle batteries.
Moreover, 5G connectivity and special economic zones that enable operations such as light assembly, labeling, and cargo consolidation. Backed by the SEM (Headquarters of Multinational Companies) regime, which offers tax and customs benefits, attracting large global players in the automotive and logistics sector like DHL and DB Schenker, using Panama as a platform to distribute goods in the region.
These strengths are especially relevant for the automotive industry, which needs agility in the delivery of critical components and finished products.

Panama's strategic advantages improve the flexibility and agility of supply chains, mitigating risks associated with a lack of capacity or disruptions in global production.
The following paper, **Driving Efficiency: Panama as a Hub for the Automotive Industry**, will delve deeper into the dynamics of this sector.

Discover more...

Notes

[1] I. D. L. Garza, «Sector Automotriz: Importancia y Principales Retos en Sostenibilidad,» BBVA , 14 June 2024. [Online]. Available: https://www.bbvacib.com/es/insights/news/bbva-cib-sector-automotriz-importancia-y-principales-retos-en-sostenibilidad/

[2] «El impacto económico de la industria del automóvil,» MOST PART, 26 December 2023. [Online]. Available: https://mospart.com/es/el-impacto-economico-de-la-industria-del-automovil/

[3] OIT, «El futuro del trabajo en la industria automotriz y la necesidad de invertir en la capacidad de las personas y el trabajo decente y sostenible,» Organizacion Internacional del Trabajo, 15 April 2020. [Online]. Available: https://www.ilo.org/sites/default/files/wcmsp5/groups/public/%40ed_dialogue/%40sector/documents/meetingdocument/wcms_741663.pdf

[4] S. Singh, «Principales tendencias que impulsan el futuro de la industria automotriz,» Forbes, 22 July 2024. [Online]. Available: https://www.forbes.com/sites/sarwantsingh/2024/07/22/top-trends-driving-the-future-of-the-automotive-industry/

[5] OMC, «Informe sobre el comercio mundial 2023,» Organización Mundial del Comercio, 2023. [Online]. Available: https://www.wto.org/spanish/res_s/booksp_s/wtr23_s/wtr23_s.pdf

[6] OICA, «2023 Production Statistics,» International Organization of Motor Vehicle Manufacturers, 2023. [Online]. Available: https://www.oica.net/category/production-statistics/2023-statistics/

[7] «Global Automotive Industry Market Size, Share, and COVID-19 Impact Analysis, By Type (Commercial Vehicle (LCVs, Heavy Trucks, Buses & Coaches), Passenger Car (Hatchback, Sedan, SUV, MUV)), By Propulsion Type (Electric Vehicle, ICE Vehicle), and By Region,» SPHERICAL INSIGHTS, February 2024. [Online]. Available: https://www.sphericalinsights.com/reports/automotive-industry-market.

[8] H. Stoddard, «Global Vehicle Sales Top 92 Million Units in 2023; December Volume Up 11%,» WARDS INTELLIGENCE, 30 January 2024. [Online]. Available: https://wardsintelligence.informa.com/wi967636/global-vehicle-sales-top-92-million-units-in-2023-december-volume-up-11

[9] S. d. E. Mexicana, «Industria Automotriz,» Pro Mexico, December 2014. [Online]. Available: https://www.gob.mx/cms/uploads/attachment/file/75545/150213_DS_Automotriz_ESP.pdf

[10] «Vehículos pesados: Definición y normativa» Webfleet, [Online]. Available: https://www.webfleet.com/es_es/webfleet/fleet-management/glossary/heavy-goods-vehicle/

[11] E. S. Bartolomé, «Qué es un vehículo especial y por qué conviene conocerlo,» EL MOTOR, 24 June 2023. [Online]. Available: https://motor.elpais.com/conducir/que-es-un-vehiculo-especial-y-por-que-conviene-conocerlo/

[12] «¿Cómo se clasifican los autos de acuerdo a su carrocería?", MITSUBISHI MOTORS, 15 June 2020. [Online]. Available: https://www.mitsubishi-motors.com.pe/blog/tipos-autos-carroceria/

[13] «¿Qué tipos de carro hay?,» KIA, [Online]. Available: https://www.kia.com/pr/discover-kia/ask/what-types-of-cars-are-there.html

[14] N. W. Mihmidati, «¡Conoce los tipos de autobuses según su modelo, tamaño y capacidad!,» TransTRACK, 3 November 2023. [Online]. Available: https://blog.transtrack.co/en/industry-trends/transportation/types-of-buses/

[15] «Clasificación de vehículos y definiciones,» Mexicocaravan, [Online]. Available: https://www.mexicocaravan.com/permits/banjercito3.pdf

[16] «Tipos de camiones: Definición, clasificación y características,» ACADEMIA DEL TRANSPORTISTA, 12 June 2023. [Online]. Available: https://www.academiadeltransportista.com/blog/tipos-camiones/

[17] P. Segui, «OVACEN,» Tipos de maquinaria construcción u obra y ejemplos, [Online]. Available: https://ovacen.com/tipos-maquinaria-construccion-obras/

[18] CAT, «25 Types of Heavy Construction Equipment and Their Uses,» Empire CAT, [Online]. Available: https://www.empire-cat.com/company/news/25-types-of-heavy-construction-equipment

[19] J. DEERE, «Equipos,» [Online]. Available: https://www.deere.com/latin-america/es/agricultura/

[20] «Flota de Vehículos,» METROPOLITAN CARE, [Online]. Available: https://metropolitancare.cl/flota-de-vehiculos/

[21] «Tipos de Vehículos de bomberos y emergencias,» 22 October 2021. [Online]. Available: https://www.kpnsafety.com/tipos-vehiculos-bomberos-emergencias/

[22] IEA, «Global EV Outlook 2024,» April 2024. [Online]. Available: https://iea.blob.core.windows.net/assets/a9e3544b-0b12-4e15-b407-65f5c8ce1b5f/GlobalEVOutlook2024.pdf

[23] «The automobile industry can lead the clean mobility movement. This is how,» WORLD ECONOMIC FORUM, 20 May 2021. [Online]. Available: https://www.weforum.org/stories/2021/05/the-future-of-automobiles-clean-energy-decarbonization/

[24] U. D. O. ENERGY, «How Do Fuel Cell Electric Vehicles Work Using Hydrogen?,» Alternative Fuels Data Center, [Online]. Available: https://afdc.energy.gov/vehicles/how-do-fuel-cell-electric-cars-work

[25] «TYPES OF ELECTRIC VEHICLES», e-AMRIT (Accelerated e-Mobility Revolution for India's Transportation), [Online]. Available: https://e-amrit.niti.gov.in/types-of-electric-vehicles

[26] «Types of electric vehicles. Complete guide to the different types of electric vehicles», Iberdrola, [Online]. Available: https://www.iberdrola.com/about-us/what-we-do/electric-mobility/types-electric-vehicles

[27] TOYOTA, «Componentes de un coche 100% eléctrico,» 2023 March 29. [Online]. Available: https://www.toyota.es/world-of-toyota/articles-news-events/componentes-de-un-coche-electrico-toyota

[28] U. D. O. ENERGY, «How Do Hybrid Electric Cars Work?,» Alternative Fuels Data Center, [Online]. Available: https://afdc.energy.gov/vehicles/how-do-hybrid-electric-cars-work

[29] «Retos En La Adopción De Vehículos Eléctricos,» FASTER CAPITAL , [Online]. Available: https://fastercapital.com/es/tema/retos-en-la-adopci%C3%B3n-de-veh%C3%ADculos-el%C3%A9ctricos.html

[30] Lee, B.-H., & Cho, S.-J., «MERGER AND RECONFIGURING OF HYUNDAI-KIA», GERPISA: The International Network of Automobile, [online]. Available: https://www.gerpisa.org/rencontre/9.rencontre/S13Lee-Cho.pdf

[31] «La Alianza Renault-Nissan-Mitsubishi abre un nuevo capítulo para su asociación,» NISSAN MOTOR CORPORATION, 08 February 2023. [Online]. Available: https://mexico.nissannews.com/es-MX/releases/la-alianza-renault-nissan-mitsubishi-abre-un-nuevo-capitulo-para-su-asociacion#

[32] «Who owns Land Rover?,» Land Rover, [Online]. Available: https://www.landrovermissionviejo.com/brand-information/who-owns-land-rover/

[33] «Geely, Dueño de Volvo,» GEELY, [Online]. Available: https://www.geely.com.ec/geely-duena-de-volvo

[34] «Daimler, nueva era como Mercedes-Benz Group,» CADIMAR, 02 February 2022. [Online]. Available: https://grupocadimar.com/daimler-nueva-era-como-mercedes-benz-group/

[35] «Daimler Truck launched on stock exchange as an independent company,» Daimler Truck, 12 December 2021. [Online]. Available: https://www.daimlertruck.com/en/newsroom/pressrelease/daimler-truck-launched-on-stock-exchange-as-an-independent-company-51850448

[36] «La fusión de FCA y Groupe PSA ha sido completada,» 16 January 2021. [Online]. Available: https://media.stellantisnorthamerica.com/newsrelease.do?id=22462&esp=si&mid=

[37] M. Carlier, «Principales fabricantes de automóviles por ventas en 2023,» Statista, 11 July 2024. [Online]. Available: https://www.statista.com/statistics/1419835/leading-car-manufacturers-by-cumulative-sales/

[38] Irle, R. (2024, January 22). Global EV Sales for 2023. EV Volumes. https://ev-volumes.com/news/ev/global-ev-sales-for-2023/

[39] «Toyota y Subaru acuerdan el desarrollo conjunto de una plataforma específica para vehículos eléctricos,» Toyota, 06 June 2019. [Online]. Available: https://prensa.toyota.es/toyota-y-subaru-acuerdan-el-desarrollo-conjunto-de-una-plataforma-especifica-para-vehiculos-electricos/

[40] Campbell, J., (2024, October 9). «Toyota, Subaru to launch new electric SUV in 2026, expanding EV partnership». CBT News. https://www.cbtnews.com/toyota-subaru-to-launch-new-electric-suv-in-2026-expanding-ev-partnership/

[41] «Toyota Motor Corporation y el Grupo BMW refuerzan su colaboración para avanzar hacia la sociedad del hidrógeno,» TOYOTA, 05 September 2024. [Online]. Available: https://prensa.toyota.es/toyota-motor-corporation-y-el-grupo-bmw-refuerzan-su-colaboracion-para-avanzar-hacia-la-sociedad-del-hidrogeno/

[42] «Nueva furgoneta Toyota PROACE MAX 2024,» Toyota, 2024, September 17. [Online]. Available: https://prensa.toyota.es/la-nueva-toyota-proace-max/

[43] «Ford y Volkswagen firman acuerdos para el desarrollo conjunto de vehículos comerciales, eléctricos y de conducción autónoma,» Ford, 10 June 2020. [Online]. Available: https://media.ford.com/content/fordmedia/fna/mx/es/news/2020/06/10/ford-volkswagen-sign-agreements-for-joint-projects.html

[44] «GM y Hyundai firman un Memorándum de Entendimiento para explorar la colaboración en vehículos, cadena de suministro y tecnologías de energía limpia,» GM, 12 September 2024. [Online]. Available: https://media.gm.com/media/mx/es/gm/news.detail.html/content/Pages/news/mx/es/2024/sep/GM-Hyundai-firman-Memorandum-Entendimiento.html

[45] J. E. J. Sánchez, «UN ANÁLISIS DEL SECTOR AUTOMOTRIZ Y SU MODELO DE GESTIÓN EN EL SUMINISTRO DE LAS AUTOPARTES,» SECRETARÍA DE COMUNICACIONES Y TRANSPORTES, 2006. [Online]. Available: https://imt.mx/archivos/publicaciones/publicaciontecnica/pt288.pdf

[46] F. Velosa y R. Kumar, «The Automotive Supply Chain: Global Trends and Asian Perspectives,» Asian Development Bank , January 2002. [Online]. Available: https://www.adb.org/sites/default/files/publication/28439/wp003.pdf

[47] B. Kesvin, «Por qué el buen diseño de un camión no solo es cuestión de una apariencia excelente,» VOLVO TRUCKS, 6 February 2024. [Online]. Available: https://www.volvotrucks.es/es-es/news/insights/articles/2024/feb/why-good-truck-design-is-not-just-about-looks.html

[48] «Diseño de coches: el automóvil del mañana en solo 7 pasos,» BMW, 7 August 2018. [Online]. Available: https://www.bmw.com/es/design/diseno-de-coches-en-7-pasos.html

[49] «Aerodinámica,» RENTING FINDERS, [Online]. Available: https://rentingfinders.com/glosario/aerodinamica/

[50] «Automotive Supply Chain Management: Everything You Need to Know,» Intellinet Systems, 27 August 2024. [Online]. Available: https://www.intellinetsystem.com/blogs/automotive-supply-chain-management-trends

[51] «Vehicle transport by cargo plane at a negotiated rate,» EXCELJETS, [Online]. Available: https://www.excelljets.net/en/private-flights/air-freight/cars/

[52] S. Unger, «BMW Group stays on track for success in 2022: Maintains No. 1 position in global premium segment, doubles electric sales,» BMW GROUP, 01 January 2023. [Online]. Available: https://www.press.bmwgroup.com/global/article/detail/T0407340EN/bmw-group-stays-on-track-for-success-in-2022:-maintains-no-1-position-in-global-premium-segment-doubles-electric-sales?language=en

[53] C. Oropeza, «Foton refuerza su liderazgo con tecnología de punta y servicio postventa personalizado,» GLOBOVISION, 15 October 2024. [Online]. Available: https://www.globovision.com/la-buena-nota/28911/foton-refuerza-su-liderazgo-con-tecnologia-de-punta-y-servicio-postventa-personalizado

[54] C. Shen, P. Sowik y A. Beach, «Investigating the U.S. battery supply chain and its impact on electric vehicle costs through 2032,» THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION, 21 February 2024. [Online]. Available: https://theicct.org/publication/investigating-us-battery-supply-chain-impact-on-ev-costs-through-2032-feb24/

[55] «How to navigate sustainability in the automotive industry,» WORLD ECONOMIC FORUM, 2 May 2024. [Online]. Available: https://www.weforum.org/stories/2024/05/how-to-navigate-sustainability-in-the-automotive-industry/

[56] «Lo que hay que saber sobre las cero emisiones netas,» GRUPO BANCO MUNDIAL , 23 May 2022. [Online]. Available: https://www.bancomundial.org/es/news/feature/2022/05/23/what-you-need-to-know-about-net-zero

[57] MAERSK, «Roadmap to Net Zero Automotive Supply Chain,» 2023. [Online]. Available: https://image.e.maersk.com/lib/fe4111727164047c771470/m/1/G-Auto-SustainabilityWhitePaper-1-Final_July.pdf?utm_source=salesforce_mc&utm_medium=email&utm_campaign=&utm_term=Thankyou_GF_Email_Block+Download+the+white+Paper&utm_content=262bdf8d9063a20e8d5760

[58] «Green Deal: EU agrees new law on more sustainable and circular batteries to support EU's energy transition and competitive industry,» European Commission, 8 December 2022. [Online]. Available: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7588

[59] IEA, «Global EV Outlook 2022,» May 2022. [Online]. Available: https://www.iea.org/reports/global-ev-outlook-2022

[60] O. M. D. COMERCIO, «INFORME SOBRE EL COMERCIO MUNDIAL 2023,» 2024. [Online]. Available: https://www.wto.org/spanish/res_s/booksp_s/wtr23_s/wtr23_s.pdf

[61] T. W. House, «BUILDING RESILIENT SUPPLY CHAINS, REVITALIZING AMERICAN MANUFACTURING, AND FOSTERING BROAD.BASED GROWTH,» 100-Day Reviews under Executive Order 14017, June 2021. [Online]. Available: https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf
https://www.bis.doc.gov/index.php/documents/technology-evaluation/2958-100-day-supply-chain-review-report/file

[62] H. G. M. M. P. Dransfeld, «Automotive digital transformation in uncertain times, The Center for Automotive Research,» 2024. [Online]. Available: https://www.cargroup.org/wp-content/uploads/2024/03/Automotive_digital_transformation_uncertain_times_Whitepaper.pdf

[63] C. Juárez, «Latinoamérica como jugador estratégico en la producción de materias primas para IA y transición energética» The LOGISTICS WORLD, 2 september 2024. Available: https://thelogisticsworld.com/manufactura/latinoamerica-como-jugador-estrategico-en-la-produccion-de-materias-primas-para-ia-y-transicion-energetica/

[64] N. CEPAL, "Lithium extraction and industrialization: opportunities and challenges for Latin America and the Caribbean," July 2023. [Online]. Available: https://www.cepal.org/en/publications/48965-lithium-extraction-and-industrialization-opportunities-and-challenges-latin

[65] Lithium: Here’s why Latin America is key to the global energy transition. (2024, September 10). World Economic Forum.
Available:
https://www.weforum.org/stories/2023/01/lithium-latin-america-energy-transition/

[66] V. López Hernández, I. Hilbert , L. Gascón Castillero , A. Manhart , D. García , B. NKongdem, R. Dumitrescu, C. G. Sucre and C. Ferreira Herrera, "Reciclaje y reúso de baterías de litio en América Latina y el Caribe: revisión analítica de prácticas globales y regionales (Nota técnica del BID ; 2893)," February 2024. [Online].
Available:

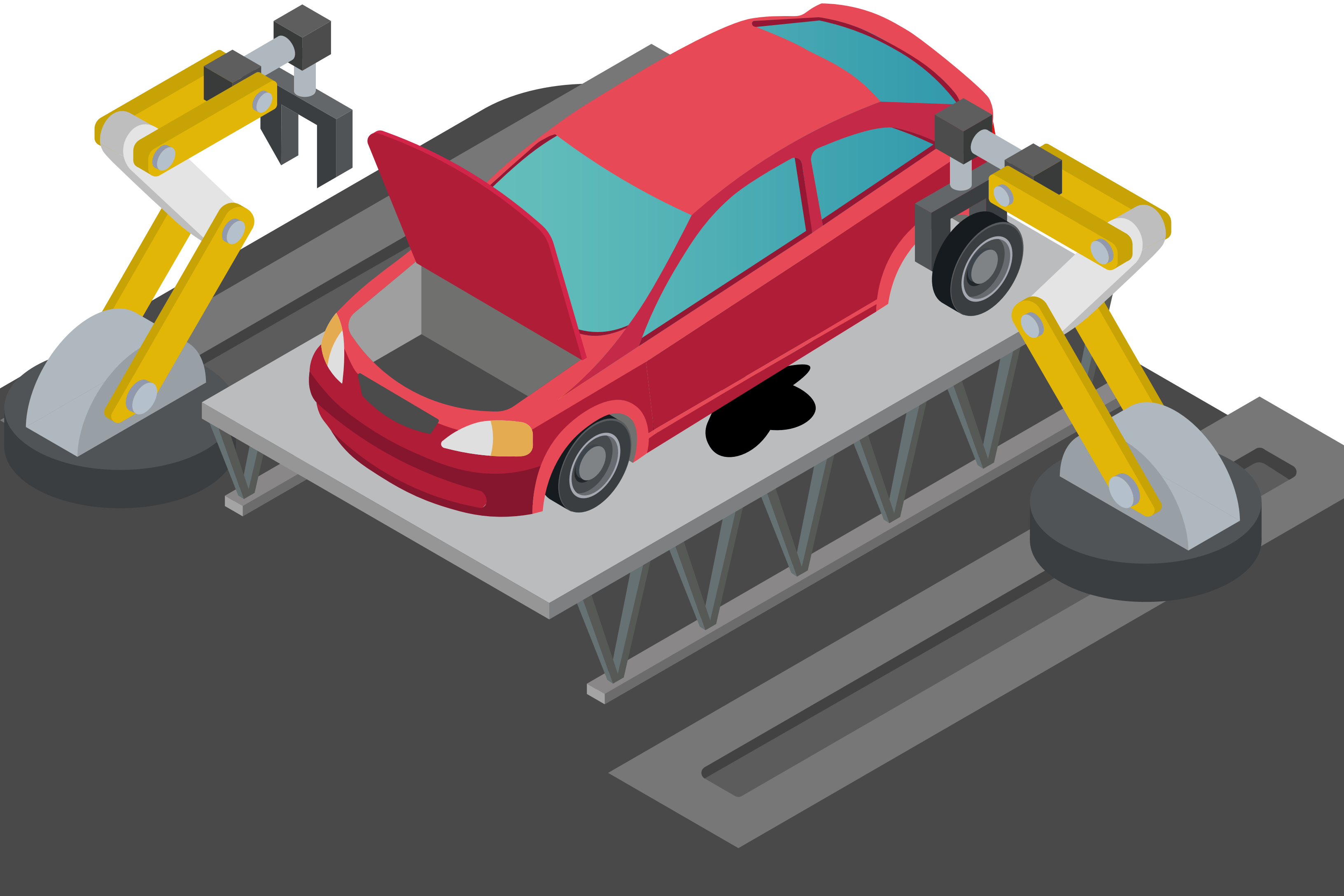
https://residuoselectronicosal.org/wp-content/uploads/2024/03/Reciclaje-y-reuso-de-baterias-de-litio-en-America-Latina-y-el-Caribe-revision-analitica-de-practicas-globales-y-regionales.pdf

[67] J. P. Zagorodny, “Gestión integral de las baterías fuera de uso de vehículos eléctricos en el marco de una estrategia de economía circular”, serie Medio Ambiente y Desarrollo, N° 173 (LC/TS.2023/36), Santiago, Comisión Económica para América Latina y el Caribe (CEPAL), 2023. Available:
https://repositorio.cepal.org/server/api/core/bitstreams/32b22cd4-cea7-4bda-bbd0-6f29309d0cb1/content

[68] Powering the Supply Chain Revolution: Addressing the Impact of Electric Vehicle Requirements on Supply Chains. (November 2024). The CSR Company International.
https://www.csr-company.com/node/6252

[69] F. Kuhnert, C. Stürmer y A. Koster, «Five trends transforming the Automotive Industry, 2017-2018,» PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft, 2018. [Online]. Available:
https://www.pwc.es/es/publicaciones/automocion/assets/five-trends-transforming-automotive-industry.pdf

[70]Automotive Industry Semiconductor Outlook. (2022). In BCG.
https://web-assets.bcg.com/5e/f8/953dc62240ddb4207dd751edda86/tracking-the-next-phase-of-the-automotive-semiconductor-shortage.pdf
TTTT T



About the **Why Panama** Program

?

In the current dynamic global landscape, it is clear that having access to high-quality insights is crucial when determining the optimal location for regional distribution in order to take advantage on the present structure of global value chains.

Georgia Tech Panama Logistics Innovation & Research Center recognizes the importance of key insights in the decision-making process, and works closely with companies seeking to assess their supply chains and how Panama can become a key part of their global logistics network.

The "Why Panama" program utilizes quantitative data and analytics to assess key variables and compare the costs, investments, and service benefits of setting up a distribution center in Panama. By conducting a thorough analysis, the program aims to provide businesses with valuable insights into the advantages of establishing a hub in Panama.

To know more you can contact Jeancarlos Chen at **jeancarlos.chen@gatech.pa** or Jorge Barnett at **jorge.barnett@gatech.pa**

WRITTEN BY

Angela Agudelo

EDITED BY

Jeancarlos Chen

Kristel Suárez

Sahian Rosales

Jorge Barnett

ILLUSTRATED BY

Luis Anzaldo

About Us

The Georgia Tech Panama Logistics Innovation and Research Center is located in Panama City, Panama. It was launched in 2010 by an agreement between the Georgia Institute of Technology and the Goverment of Panama through the National Secretariat of Science, Technology and Innovation (SENACYT).

Reach us at **www.gatech.pa**

Georgia Tech Panama
Logistics Innovation & Research Center

An innovation center of SENACYT
Secretaría Nacional de Ciencia, Tecnología e Innovación

CONTACT US

(+507) 395-3030

georgiatechpanama@gatech.pa

gatechpanama