KEY DATA ON THE AUTOMOTIVE SECTOR

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Contents

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Introduction

This report describes the economic trends in the global automotive industry over the past decade and sets out the main challenges faced by the sector.

After being strongly affected by the 2008 financial global crisis and subsequent recession, the auto industry showed a remarkable rebound from 2009 onward. With traditional players more badly hit by the crisis, emerging markets were those driving the rapid recovery.

The emergence of China as number one in both production and sales is the main economic transformation in the automotive sector over the past decade. China overtook the United States in both production and sales in 2009 and has maintained its leading position without interruption since then. In 2017, China's motor vehicle production represented 30% of the world's vehicle production, with the United States in the second place accounting for 11.5%. In terms of sales, China represented 30% of world auto sales in 2017, while the US market accounted for 18%. With the rise of China, Japan moved from being number one producer in 2007 and 2008 to third place in 2017, behind China and the United States.

In the European Union, the top auto producer continues to be Germany, which ranked fourth in the world production ranking in 2017. Spain performed remarkably in the past few years, advancing four positions from 12th place in 2013 to eighth place in the world production ranking and even surpassing Canada. In Latin America, Mexico continues to grow and the recent trade deal between Mexico, the United States and Canada (the United States-Mexico-Canada Agreement of October 2018) has led Mexican suppliers to publish a very positive outlook for the coming years.

In the following chapters, we provide key data relevant to the automotive sector over the past decade. Chapter 1 gives a thorough description of the automotive world market's situation. The first two sections provide production and sales data by country and manufacturer (as of April 2018). The following sections in chapter 1 describe the main trends in international trade, vehicle use and GDP per capita, R&D expenses by country and manufacturer, and the main employment trends in the industry. Chapter 2 is organized according to the PESTEL framework, setting out and discussing the key trends and challenges of the automotive industry in politics, the economy, technology, society, environment, and regulation (as of February 2018). Finally, Chapter 3 lists manufacturer information, Chapter 4 lists key associations, and Chapter 5 provides the full references used for this report.

IESE AUTO 2018: Back to the Future

> "There is every reason to believe that the electric vehicle industry is well established on a sure foundation and that it will grow rapidly, especially in the estimation of the public, without which support no enterprise of a semi-public interest could long exist."
>
> *Editorial, Electrical World, United States, August 1897* [1]

> "At that busy corner, Grand Street and the Bowery, there may be seen cars propelled by five different methods of propulsion—by steam, by cable, by underground trolley, by storage battery, and by horses."
>
> *New York Sun, 1898* [2]

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[1] Quoted in David A. Kirsch, *The Electric Vehicle and the Burden of History* (New Brunswick, NJ: Rutgers University Press, 2000), 29.

[2] Quoted in David A. Kirsch, *The Electric Vehicle and the Burden of History* (New Brunswick, NJ: Rutgers University Press, 2000), 11.

"The electric car will occupy a wider field of usefulness in the near future than in the past, due to the improvements constantly being made and the ability of electric cars to travel much longer distances…"

Pope, Studebaker and Baker, directors on the board of the Association of Electrical Vehicle Manufacturers, United States, 1906 [3]

Historical Perspective

In 1886, Carl Benz registered the first patent for an automobile driven by an internal combustion engine. In doing so he gave birth to the automotive industry, "the industry of industries" (Drucker 1946). The Benz car, powered by a small internal combustion engine, had three wheels and can be seen in the Mercedes-Benz Museum in Stuttgart. By 1900, however, the Benz company was joined by almost 500 companies around the world, all of them producing electric cars. The electric motor had become a key form of automotive propulsion and in New York City, for example, it propelled half of the taxi fleet. Most people who could afford a car—generally the upper class—believed that the electric car would be the dominant form of future mobility.

Other elements of an electric mobility ecosystem also emerged: In 1897 the Electric Vehicle Company was founded in New York and by 1899 it had become the largest car manufacturer in the United States, putting more than 1,000 electric cars on the road. Its owner, Isaac Rice, also acquired the Electric Carriage and Wagon Company, which "pioneered a cab system that included service stations for quick change of battery sets, and repair work; vehicles were leased only, not sold."[4] Under the leadership of William C. Whitney and others, the Electric Vehicle Company "hoped to develop a monopoly by placing electric cabs on the streets of major American cities, starting with New York City, Philadelphia, Chicago, Washington, D.C., and Boston."[5] Around a century later, other companies are trying to achieve the same goal, albeit on a global scale (DiDi, Uber, Lyft, etc.).

By 1906 a battery exchange system had been developed in Hartford, Connecticut. Customers could buy a car without a battery and pay a flat fee to swap batteries in their cars. In 1910 the Philadelphia and Baltimore area had 27 battery charging stations, feeding a fleet of electric vehicles. New York and Chicago had similar systems. At the same time, the Electric Carriage and Wagon Company was the first to sell mobility services via its electric cabs rather than selling cars. Today, more than a century later, several of these 19th-century business models are reemerging in a data-driven form: the system of fast battery swaps was "reinvented" by Better Place, a Silicon Valley start-up founded in 2007. It filed for bankruptcy in 2013, after going through $850 million of funding.

The idea of selling mobility services rather than cars reemerged with Daimler's Car2go and BMW's DriveNow service offerings (among others), enriched by connectivity. The electric car itself was taken to a new level when Tesla added connectivity and data-driven management. In doing so it also brought many concepts from IT to the automotive industry, such as a relentless focus on customer experience, frequent updates, and data collection, to name a few. The company thus gave an innovation shock to the industry.

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[3] Quoted in David A. Kirsch, *The Electric Vehicle and the Burden of History* (New Brunswick, NJ: Rutgers University Press, 2000), 29.

[4] "Electric Vehicle Company," Wikipedia, last modified March 1, 2018, https://en.wikipedia.org/wiki/Electric_Vehicle_Company.

[5] "Electric Vehicle Company," Wikipedia, last modified March 1, 2018, https://en.wikipedia.org/wiki/Electric_Vehicle_Company.

These examples show that many of the ideas emerging today are not new but have been taken to a new level by the availability of digital technology. The question is: Will the coming years lead to a similar change in mobility as was seen at the beginning of the 20th century?

Looking back, we see that the initial success of electric vehicles in the late 19th and early 20th century did not last very long. By the beginning of the First World War, most electric cars had disappeared from roads around the world, replaced by gasoline-powered cars.

Several reasons for this can be identified and they allow for some interesting reflections about today's situation. First, when electric vehicles reached a market share of up to 40% of the fleet size in some US cities at the beginning of the 20th century, they were used to travel within urban environments where streets, many of them asphalted, were available. Long-distance travel, such as from New York City to Boston, was still the domain of horse-drawn carriages as roads were in poor condition and recharging stations for electric vehicles were not available. With the discovery of the Spindletop oil field in Texas, the United States was ushered into the oil age and petroleum and its derivatives were available in ample supply.[6] The availability of cheap petroleum generated a wide range of low-cost petroleum-based products, including asphalt. This led to a significant growth of paved streets, including long-distance roads, which enabled cars to make the journey from NYC to Boston. This immediately gave rise to the problem of the limited range of electric cars, due to the limited energy storage capacity of batteries. (A problem that still exists today.) The problem could not be addressed by battery exchange models as used in NYC or other cities (the supply logistics could not be solved) or by charging stations (infrastructure investment and the time needed to charge posed problems). More importantly, the Texas Spindletop oil field made cheap oil available in large quantities. Companies such as Gulf and Texaco emerged, with the goal of refining oil into gasoline and its related products. Bertha Benz, the wife of Carl, had to get her gasoline from a pharmacy during the first long-distance car drive in 1888 but the first gas station was established in Saint Louis, Missouri, in 1905, followed by the first drive-in station set up by Gulf Refining in 1913.

On October 7, 1913, Henry Ford's team began experimenting with the moving assembly line. The results eventually reduced assembly time by 75%, allowing Ford to drop the price of his cars from $600 to $360, while doubling wages to $5 a day in January 1914.[7] The increasing disposable income of Ford workers allowed many of them to buy the products they were manufacturing, which in turn drove demand for gasoline and led to a growing network of gas stations. While Ford turned the car into a product for the masses, many manufacturers of electric vehicles still used conventional manufacturing processes, resulting in price points that were often significantly higher than that of the Model T.

A final blow was given to electric cars in 1912, when Charles Kettering invented the electric starter for gasoline engines. It solved the problem of having to crank the engine manually, a strenuous task that entailed the risk of losing a thumb if handled incorrectly. The growing network of gas stations, along with the superior range of gasoline cars and a growing network of roads, established long-distance travel by car and made it difficult for electric vehicles to compete.

[6] For a detailed history of the petroleum industry see Daniel Yergin's books *The Prize* and *The Quest*.

[7] "100 Years of the Moving Assembly Line," Ford, 2018, http://corporate.ford.com/innovation/100-years-moving-assembly-line.html. Matt Anderson, "Ford's Five-Dollar Day," The Henry Ford, January 3, 2014, https://www.thehenryford.org/explore/blog/fords-five-dollar-day/.

The availability of the small internal combustion engine and its electric starter (product innovation), the ability to store gasoline in tanks (energy source), a growing network of roads and gas stations (infrastructure) and a superior manufacturing method (process innovation) marked the end of the electric vehicle. These developments were embedded in complex interactions between social and economic structures (e.g., Ford's doubling of wages to $5 a day, which grew the middle class and generated demand), which continue to shape the emergence of large-scale, technology-based ecosystems (of which the automotive industry is one of the largest).

The Return of the Electric Car

Since the advent of the 21st century, interest in electric vehicles has increased substantially. Several reasons can be identified:

- Environment: Transportation has led to a significant increase in greenhouse gases (GHG: most of which is CO_2) and particles, decreasing air quality in urban settings.[8] Governments are therefore implementing regulations to reduce these emissions. For countries such as China, electric cars seem to be the only viable alternative to ensure quality of urban life and mobility for a growing middle class. Many politicians and the broader public are of the opinion that the electric power train is the best approach to achieve the objective of reducing GHG.

- Product and performance: The electric power train and its underlying physics (immediate torque and small build size) allow for impressive performance, especially in acceleration. The ability to recover some of the kinetic energy under braking to recharge batteries makes electric cars even more interesting from an environmental perspective. Furthermore, the small build size of electric vehicles (EVs) gives designers more freedom to develop new body shapes and make efficient use of the car's footprint. EVs can be developed without the legacy that traditional car manufacturers have to deal with (their "brand," what it stands for, key design elements, etc.). Software is a natural fit with EVs. For example, software can be used to manage the individual battery cells in their battery packs. This cell balancing ensures that the cells operate within a defined performance envelope, extending their life and reducing the risk of combustion or other incidents. Moreover, the increasing penetration of software in all areas of the car allows for a faster innovation cycle, enabling new features to be introduced even months or years after the car has left the factory. The significant amounts of data available in a car have become an object of desire for companies in Silicon Valley, which are experts at harvesting and monetizing such data. The established OEMs, however, have realized that opening the data bus of their cars to the digital champions of Silicon Valley or China would increase the risk of them becoming mere commodity manufacturers. OEMs need to learn quickly how to leverage the data that they control. This is no easy task when most computer scientists prefer to work in Silicon Valley rather than in locations where leading OEMs have their headquarters, not to mention the different company culture and salary packages. To complicate matters, most OEMs are dealing with legacy systems in their data collection (at car level) and their processing capabilities (how to collect all the data, where to store and process them and what to make of them, such as how to turn the data into value for the customer and monetize them). The same legacy problem can be found in the value chains of most established OEMs. For example, what role will dealerships have in a future of shared autonomous EV mobility? Newcomers can start

[8] It should be noted that, on a continental scale, car-related emissions are marginal: for example, less than 10% of CO_2 in Western Europe.

with a blank sheet of paper, to design a fully integrated system that will provide a superior customer experience. In an age when the acceleration or sound of a car will be far less relevant (if at all!) than full connectivity, service excellence, and the seamless integration of personal gadgets into the car's IT system, it will be these latter elements (among others) that will define the customer experience. Established OEMs are therefore under immense pressure to continue to meet shareholder expectations in terms of profitability (which basically means using traditional ICE cars as cash cows), while developing the electric power train and its new ecosystem of connected services in a world of changing mobility needs. Once again, newcomers benefit from their greenfield approach: Tesla's track record of losing money for most of its 15-year history is unthinkable for any established OEM.

- Supply chain: Electric motors have far fewer parts than internal combustion engines (ICE), so they are easier to manufacture. In a 2017 interview with the German publication *Automobilwoche*, Herbert Diess, then a board member of the VW Group, estimated that EVs will "only have 10% of the complexity of our conventional ICE vehicles."[9] This has two important implications. First, the barriers of entry to the industry are coming down, as less capital (tangible and intangible) is required. Second, many of the established suppliers will have to rethink their business models. For example, electric cars do not need complex gearboxes to intermediate between the engine rpm and wheels on the road. Instead, the electric motor can do the job with a simplified set of gears. Similar concerns apply to companies that manufacture exhaust systems, oil pumps, and turbo chargers—that is, all companies involved in the ICE power train. The know-how of managing a complex supply chain, however, will remain a key challenge in the industry, from supply base to distribution and after service. Overall the highly complex automotive value chain will be simplified and new approaches to car manufacturing might emerge. A single-purpose vehicle, such as a small EV build for urban environments and autonomous driving, might emerge in the form of a highly standardized small EV. This would simplify the supply chain and manufacturing significantly and the automotive industry might see a Foxconn-style company for cars emerge—in other words, a contract manufacturer that would mass-produce hundreds of thousands of identical small electric cars. It would do so on a highly automated production line with very little labor but with thousands of robots and Industry 4.0 elements.

- Business models: The electric power train significantly increases the level of digitization in the car and its related ecosystem. It is a logical step for OEMs to then increase the connectivity of their electric cars, both to collect data about them and also to offer new services (e.g., updating the car's software over the air). This gives rise to product-as-a-service business models, such as car and ride sharing. Driven by the digitization of the car (ICE and electric vehicles alike), the industry as a whole is undergoing significant change and many of the current CEOs openly admit that they have difficulties in predicting what the industry will look like in 2030. This transformation process will be accelerated with the entry of Industry 4.0 on the factory floor and throughout the supply chain. The incumbents face many challenges, mainly because they are caught in the asset trap. New entrants, on the other hand, are not burdened by brownfield assets and can identify many opportunities by rethinking product, process and business models. China is a showcase for an economy that has embraced the opportunity of electric vehicles. BYD, a major player in battery production, is also one of the largest manufacturers of electric vehicles (both cars and commercial vehicles). It is but one

[9] Henning Krogh, "VW-Markenchef Diess im Interview: "Wir haben eine lange Strecke vor uns"," Automobilwoche, no. 24 (November 2017).

example of several dozen Chinese companies that develop electric vehicles in an environment fostered by the Chinese government. China sees the automotive industry as a strategic industry and the electric car as an opportunity to leapfrog established players in the West. In doing so, Chinese companies can leverage their strategic advantage of having access to vast amounts of customer data, strong developments in artificial intelligence (a key element for autonomous driving) and being able to take a greenfield approach. China also benefits from the large number of engineering students graduating from its top universities, a number made larger by the fact that the current US administration is making it more difficult for foreign students to enter the top US research universities active in the field of mobility (e.g., Stanford, Carnegie Mellon and MIT), which traditionally attracted many of China's top students. With the coming opening of China to foreign direct investment (not limited by joint-venture restrictions), however, it remains to be seen how many of the dozens of EV companies operating in China today will become a Chinese version of the Volkswagen Group or Toyota, building millions of vehicles each year—and making money doing so.

- **Market**: Millennials and younger generations attach more value to their smartphone than to owning a car. This change in perception has made the automotive industry's traditional marketing tools (e.g., a focus on performance and quality) less effective. Furthermore, as more and more people live in urban areas, the daily experience of traffic congestion does not help to make the privately owned car an interesting value proposition. Instead, mobility services in the form of car and ride sharing offered by companies such as Drive Now and DiDi are more attractive to younger generations such as millennials. The growth rate of these services is significant, reflected in the valuation of such players as DiDi and Uber. This growth can be attributed to the reluctance to own such a costly asset as a car but also to the superior customer experience provided by mobility services. Car sharing represents a significant challenge to established OEMs as they make most of their profits from large cars while A- and B-segment cars—which are perfectly suited to the requirements of urban mobility—provide marginal profits, at best.

With the adoption of electric vehicles, driven by the factors outlined above, traditional car makers are under significant pressure to innovate their products, processes and business models. Given the reflections above, it may well be the newcomers rather than the established OEMs that will define the future of the automotive industry.

Challenges for the Electric Car

While the public opinion has turned to the electric car as a smart solution for mobility and to reduce emissions, several questions need to be addressed and clarified before its widespread use would make sense. These include the following:

- **Battery cost:** One of the key elements of any electric car is the battery, particularly the lithium-ion (Li-ion) cells (currently the most widely used technology for battery electric vehicles or BEVs). Cars require more sophisticated batteries than smartphones. Car batteries need to meet stringent targets for cost, rated kWh capacity, specific energy, specific power, peak power, state of charge, depth of discharge, cycle life, and battery reversal (to name a few).[10] Compared to smartphones, cars have to operate in a far broader temperature range, are used for much longer (about 10 years in Europe) and

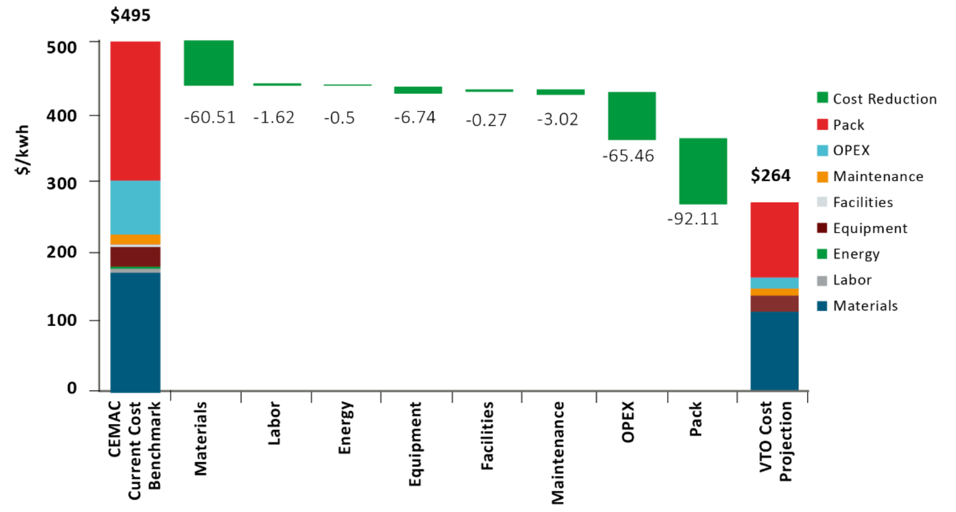
[10] For more details see Kwo Young, Caisheng Wang, Le Yi Wang, and Kai Strunz, "Electric Vehicle Battery Technologies," in *Electric Vehicle Integration Into Modern Power Networks*, ed. Rodrigo Garcia-Valle and João A. Peças Lopes (New York: Springer, 2013), 15–56.

have to fulfill more complex safety requirements (e.g., crash tests). This makes battery packs for cars more difficult to manufacture and more expensive. A report published in 2010 estimated the cost of installed battery packs at around $1,000 per kWh. The report predicted that by 2020 costs would drop by more than 60% to around $400 per kWh.[11] In 2015, Nykvist and Nilsson collected public data on battery costs for electric cars and put the average cost at $400 per kWh that year (with outliers ranging from $250 to $500). The authors estimated an average cost of $300 per kWh for Tesla (without power electronics and a battery management system). This put the cost of the battery pack of a Tesla Model S P85D (the most powerful model available in 2014) at a minimum of $25,500, which was the MSRP of a brand new Ford F-150 pickup, the best-selling vehicle in North America. The authors stated:

> We reveal that the costs of Li-ion battery packs continue to decline and that the costs among market leaders are much lower than previously reported.
>
> ... it is indeed possible that economies of scale will continue to push the costs towards US$200 per kilowatt in the near future even without further cell chemistry improvements. However, these cost reductions depend on the successful implementation of these large scale battery production facilities and on continued public support through, for example, economic incentive schemes in key BEV markets.[12]

Figure 1

Li-Ion Battery Costs, 2015 vs. 2017



Source: US Department of Energy, *Cost and Price Metrics for Automotive Lithium-Ion Batteries*, February 2017, 3, https://www.energy.gov/sites/prod/files/2017/02/f34/67089%20EERE%20LIB%20cost%20vs%20price%20metrics%20r9.pdf.

A report published in February 2017 by the US Department of Energy (DOE) estimated that costs could fall to about $200 per kWh by 2020 in a best-case scenario of technological advances and high-volume production.[13] Several reports estimate that,

[11] Boston Consulting Group (BCG), *Batteries for Electric Cars*, 2010, https://www.bcg.com/documents/file36615.pdf.

[12] Björn Nykvist and Måns Nilsson, "Rapidly Falling Costs of Battery Packs for Electric Vehicles," *Nature Climate Change* 5 (2015): 329–332.

[13] US Department of Energy, *Cost and Price Metrics for Automotive Lithium-Ion Batteries*, February 2017, 3, https://www.energy.gov/sites/prod/files/2017/02/f34/67089%20EERE%20LIB%20cost%20vs%20price%20metrics%20r9.pdf.

sometime between 2022 and 2026, battery costs will drop to the critical threshold of $150, implying cost parity between electric and ICE vehicles. For 2017, the DOE report still puts the cost at more than $200 per kWh.[14] (See **Figure 1**.) In this context, the raw materials used to produce batteries play a crucial role. In the case of electric cars, the automotive industry finds itself exposed to a fierce competitor for raw materials: the consumer electronics industry. Both industries need access to the same minerals and rare earth elements, giving rise to significant price swings. For example, the price of cobalt, a key material used in the production of batteries, has increased threefold between 2016 and 2018. Astute investors may see a unique opportunity to play the markets, benefiting from temporary supply shortages. Furthermore, mineral deposits of several key ingredients of Li-ion batteries can be found in politically unstable regions in Africa (e.g., in 2017 some 60% of the world production of cobalt came from the Democratic Republic of Congo) or in nations with a geostrategic agenda (e.g., China, which has acquired seven of the 10 largest cobalt producers of cobalt).[15]

- **Financial and fiscal considerations**: Comparisons of the total cost of ownership (TCO) for traditional cars and EVs often ignore the fact that taxes paid for hydrocarbons at the pump put traditional cars at a disadvantage. In many European countries, the tax levied on hydrocarbons used for cars is up to seven times higher than that used for energy generation. Governments of larger countries such as France and Germany would have to find ways to compensate for this lost revenue stream.

- **Energy mix**: In the discussion of the advantages of electric mobility, often comparisons are made between the current ICE system and the EV system without ensuring comparable system boundaries. A typical example for this is the focus on tailpipe emissions: everybody can see that, unlike traditional cars, EVs generate no tailpipe emissions. So, obviously, the electric car must be better. Some doubts arise, however, as the tailpipe focus fails to include the source of energy for the EV—that is, the generation of electricity. Several studies have analyzed the effect of EVs by including energy generation within the system boundaries. A study by Holland et al. (2015)[16] may serve as an example. The authors find that, given the energy footprint in the United States, EVs should be taxed(!) at up to $5,000 at the time of purchase in the East Coast and Midwest states, where electricity generation is primarily carbon-based. On the West Coast, where renewable energy represents a significant percentage of the energy mix (e.g., hydro power from the Columbia river system), the authors find that subsidies of up to $5,000 would make sense. This example illustrates that system boundaries have a sizable effect on the environmental performance of battery electric or ICE vehicles.[17] It also makes a strong case for improving the energy mix in Europe and North America. The results of Holland et al. (2015) show that, with the wrong energy mix, electric vehicles shift CO_2 and nitrogen oxide (NO_x) emissions from inner cities to rural areas, where power generation plants are located. Similar insights apply to Europe and China,

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[14] See also Bloomberg New Energy Finance, *Global EV Trends*, 2017.

[15] Elisabeth Behrmann, Jack Farchy, and Sam Dodge, "Hype Meets Reality as Electric Car Dreams Run Into Metal Crunch," Bloomberg, January 11, 2018, https://www.bloomberg.com/graphics/2018-cobalt-batteries.

[16] Stephen P. Holland, Erin T. Mansur, Nicholas Z. Muller, and Andrew J. Yates, "Environmental benefits from driving electric vehicles?", NBER Working Papers Series 21291, National Bureau of Economic Research, 2015, http://www.nber.org/papers/w21291.pdf.

[17] BEVs are pure electric vehicles, while the category of electric vehicles (EVs) generally also includes plug-in hybrid EVs (PHEVs). The latter hybrids have both an ICE and an electric motor, and batteries can be recharged by connecting the car to an electricity outlet (hence "plug-in").

where the current energy mix is unsuitable for supporting the widespread introduction of EVs, which would increase GHG emissions rather than reduce them. The Chinese government has responded by building multiple nuclear power plants, exchanging CO_2 and NO_x for nuclear waste.[18]

- Cradle-to-grave: Discussions of electric mobility increasingly include the topic of the energy mix, as discussed in the previous paragraph. A full assessment of the environmental impact, however, needs to include the emissions generated during the mining of raw materials for battery production (cradle) and end-of-life (grave) considerations—that is, the eventual disposal of spent batteries. Current battery and electric motor technology requires significant amounts of rare earth elements. These elements are not rare as such but their concentration in the earth's crust is very low. As a result, significant volumes of material have to be mined and processed to produce relatively small amounts of these materials, particularly when virgin materials are used. The Argonne National Laboratory in Illinois reviewed scientific literature on this topic.[19] Analyzing the results of several publications on cradle-to-gate[20] emissions, its authors found that, during the production of a 1 kg Li-ion battery, 12.5 kg of CO_2 and 14.5 g of NO_x were generated on average. (This excludes the usage cycle of the battery—that is, emissions from electricity generation during the use of the battery.) This would translate into close to 10 tons of CO_2 and more than 8 kg of NO_x generated during the production of the battery pack of a Tesla Model S P100D. By way of comparison, a diesel car that meets stringent Euro 6 regulation requirements could drive several thousand kilometers before reaching the same level of CO_2 or NO_x emissions. In many comparisons of ICE and battery electric vehicles, these initial emissions are ignored. At the end of their life cycle, batteries need to be disposed. This also presents a challenge, given the concentration of metals such as cadmium and other elements. An interim solution is the second life use of batteries: once their capacity has faded to 70% of its original value, the batteries are decommissioned from EVs and used as fixed electricity storage in domestic or business settings.[21] They can play an important role in smart grid solutions, which in turn help with the introduction of regenerative "green" electricity generation and distribution. For the next few years, many of the batteries that are removed from EVs could be absorbed into this market. In many countries, however, the lack of suitable business models and the presence of regulatory hurdles limit the absorption rate. Strong growth of domestic battery packs to store renewable energy would generate challenges in relation to keeping the electricity grid stable and the energy utilities profitable. While the absorption rate of used battery packs into second life usage will increase in the near term, eventually it will reach a steady state and the battery packs will have to be disposed of at a rate that is similar to the rate of decommissioning—that is, several

[18] At the start of 2018, China had 20 nuclear power plants under construction, with more to follow. See: "Nuclear Power in China," World Nuclear Association, last modified September 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx.

[19] John Lorenzo Sullivan and Linda Gaines, *A Review of Battery Life-Cycle Analysis: State of Knowledge and Critical Needs* (Oak Ridge, TN: Argonne National Laboratory, US Department of Energy, 2010), https://greet.es.anl.gov/files/batteries_lca.

[20] Cradle-to-gate: from mining of raw materials to batteries leaving the factory gate

[21] As the number of loading cycles of a battery pack increases, its capacity to hold energy decreases. This is called "fading." The National Renewable Energy Laboratory in Colorado has found that Li-ion batteries "typically fade in a graceful manner from beginning through the middle of their lifetime" but after that, however, "performance can sometimes rapidly degrade" (Kandler Smith, "Battery-Life Trade-Off Studies," in IV. Battery Testing, Analysis and Design, Energy Storage R&D FY 2013 Annual Progress Report, US Department of Energy, 134, https://www.energy.gov/sites/prod/files/2014/05/f15/APR13_Energy_Storage_e_IV_Battery_Tstg_Design_2.pdf).

million cars per year in Europe. China, which has taken a lead in electric mobility, is already facing some of these challenges. It could be facing a volume of 170,000 tons of lithium battery waste in 2018 and this volume will increase steadily with the government-induced adoption of EVs.[22] To put this in perspective: Europe's largest installation for recycling Li-ion batteries has a capacity of 20,000 tons per year, with an overall installed capacity in Europe of less than 45,000 tons.[23] Similar numbers apply to China, where some recycling companies see no business case for Li-ion batteries as recycling costs outweigh potential revenues.[24] In 2016, there was a shortage of appropriate policies and collection systems for batteries in China, despite growing community concern about the impact of waste lithium-ion batteries on the environment and public health.[25] Once the recycling capacity is available, however, reverse logistics becomes a challenge: to ensure an efficient circular economy, the recycling system must achieve a high collection rate of used battery packs—and a high efficiency rate in the recycling process itself. To be economically viable, recycling facilities need to be on an industrial scale, which requires significant investment. In a recent study, Hendrickson et al. (2015) analyzed the supply chain logistics of battery recycling in California and concluded that two recycling facilities would be the best solution to balance economic and environmental constraints.[26] To keep the facilities operating at high utilization levels, there would an industrial-scale inflow of used batteries. Reverse logistics becomes an interesting problem in this setting as, for the foreseeable future, diesel-powered trucks will have to transport the spent batteries to the recycling facilities.

- Efficiency: Another argument often used by proponents of the electric vehicle is the transformation of electric energy into kinetic energy: electric motors easily achieve an efficiency of more than 90%, while the best internal combustion engines achieve 40% (diesel) or less (gasoline). Focusing on the high efficiency of the electric motor leads to a failure to take account of the transformation process of chemical energy into electric energy that is happening in the electricity plant. In a 2017 study, Teufel et al.[27] point out that, if the whole energy chain is considered, both forms of propulsion translate only about 30% of primary energy (e.g., hydrocarbons) into kinetic energy. What is worse, the diesel engine fares better than the electric motor. The authors point out, however, that the use of regenerative electricity generation will improve the balance for the electric motor, eventually making it superior.

[22] David Stanway, "China's Recyclers Eye Looming Electric Vehicle Battery Mountain," Reuters, October 23, 2017, https://www.reuters.com/article/us-china-batteries-recycling-insight/chinas-recyclers-eye-looming-electric-vehicle-battery-mountain-idUSKBN1CR0Y8.

[23] A Tesla Model S P100D carries a battery pack of about 800 kg, which would translate to a total recycling capacity of 50,000 vehicles compared to annual new car sales in Western Europe of 14.2 million units. (Note: The Tesla Model S P100D has the largest battery pack of all passenger EVs.)

[24] Stanway (2017): "one recycling company [was cited] as saying that the value of materials extracted from one tonne of lithium-iron-phosphate battery waste stood at 8,110 yuan, but the cost of recycling them would be 8,540 yuan."

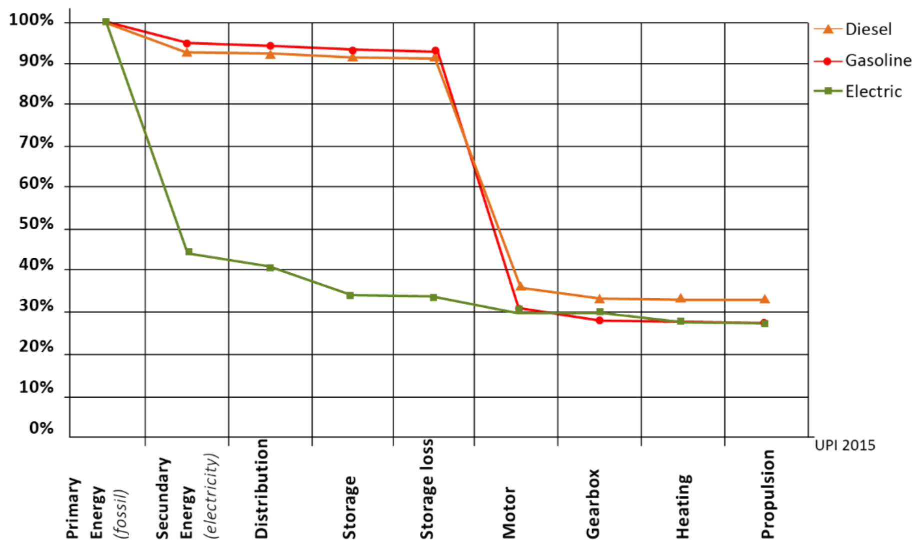
[25] Stanway (2017).

[26] Thomas P. Hendrickson, Olga Kavvada, Nihar Shah, Roger Sathre, and Corinne D Scown, "Life-Cycle Implications and Supply Chain Logistics of Electric Vehicle Battery Recycling in California," *Environmental Research Letters* 10, no. 1 (2015).

[27] Dieter Teufel, Sabine Arnold, Petra Bauer and Thomas Schwarz, *Ökologische Folgen von Elektroautos*, Umwelt- und Prognose- Institut (UPI), Bericht Nr. 79 (report no. 79), 2nd ed., 2017, http://www.upi-institut.de/UPI79_Elektroautos.pdf. The UPI is an independent research institute, based in Heidelberg, Germany.

Figure 2

Energy Efficiency of Cars



Source: "Energieausnutzung PKW," Teufel et al. (2017, 47).

- **Natural resources**: Li-ion batteries for EVs include a broad range of materials, such as lithium (Li), nickel (Ni), cobalt (Co), manganese (Mn), aluminum (Al), copper (Cu), silicon (Si), tin (Sn), titanium (Ti) and carbon (C) in a variety of forms. Of these, cobalt, natural graphite and silicon metal fall into the category of critical raw materials, meaning that they are of great economic importance and there is a high supply risk.[28] With the growth of electric mobility, the supply of cobalt will come under pressure and the European Commission estimates that, by 2050, "the cumulative demand for cobalt would require all the resources known today, even considering its relatively high recycling rate in the battery sector."[29] Recent price movements of cobalt give an indication of this development. In practically all areas that are relevant to the production of batteries for electric vehicles, China plays a leading or important role. The Chinese government moves very strategically (e.g., helping Chinese companies to acquire cobalt deposits in Congo, effectively banning ICE cars from large cities in China, and increasingly regulating foreign car manufacturers in China) and the current tectonic change of the automotive industry provides a unique opportunity for China to leapfrog established players from Europe, Japan, North America and South Korea.

Outlook

The electric car is part of a new ecosystem. It will be able to deliver its full potential only if it is supported by a new charging infrastructure, a clean energy mix, green factories, innovation to reduce the dependence on some critical minerals (such as cobalt), intelligent design to limit the size of the battery, and a circular economy that makes intelligent use of recycled materials. It remains doubtful whether

[28] See the "Critical Raw Materials" list published by the European Commission on a regular basis: http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en.

[29] Natalia Lebedeva, Franco Di Persio, and Lois Boon-Brett, *Lithium Ion Battery Value Chain and Related Opportunities for Europe*, JRC Science for Policy Report (Petten, Netherlands: European Commission, 2016), 9, https://ec.europa.eu/jrc/sites/jrcsh/files/jrc105010_161214_li-ion_battery_value_chain_jrc105010.pdf.

BEVs with large batteries are a way to help the environment, given the problems outlined above. Furthermore, these cars do not help solve another key problem: congestion in urban environments.

A car that has the potential to solve all of these challenges would be a small, electric, connected pure urban vehicle. Small, because this size would reduce the footprint and thereby help to reduce congestion and parking problems in urban settings. To get similar utility from a small car as current midsize cars, it would be necessary to make efficient use of its small footprint. Using an electric power train would help to achieve this goal: wheel-hub engines would move the motor from body to wheels, while the battery and power electronics could be located in the floor of the car, giving a lot of space to passengers and storage. Making it a purely urban car would eliminate two challenges traditional car makers have to solve. The first is range anxiety — the ability to drive the car for 500 km or more before refueling. A purely urban car would have to cover significantly smaller distances and, given the right infrastructure, it would be charged at many locations across a city. The second typical challenge is that of passenger safety: traditional cars are very expensive to develop, in part because they have to meet stringent crash tests at varying speeds. A car designed for urban environments can be limited to a top speed of 80 km/h, thereby reducing the need for complex safety engineering. This would also reduce its mass, in turn reducing its energy needs. The limit to urban settings would also make the wheel-hub engine a viable alternative, as its disadvantages in terms of handling and drive dynamics would be less of an issue. Making it connected would allow it to be used in different business model settings (e.g., ownership and shared models) and would be a prerequisite for autonomous driving. Last but not least, a small, electric pure urban vehicle would not need a large battery, thereby reducing some of the negative externalities outlined above.

Several implications can be identified. First, the structure of the value chain will change. Small, connected urban electric vehicles have far lower service requirements than traditional cars. OEMs will be tempted to sell them directly to the user, bypassing dealerships. Manufacturers will not be able to do so, however, as long as most of their revenue stream is generated by this traditional distribution channel. It may be assumed that a new form of value generation among the different players in the value chain will emerge. In this transition process, dealerships will be under significant pressure to change and stay profitable. Second, OEMs will also be affected. A small, electric, connected pure urban vehicle has a low product complexity and a much simpler supply chain and therefore could be produced more easily and at a significantly lower cost. The growth of younger user segments has the potential to make the car hardware more of a commodity: these segments put less importance on the exterior design of the car but much more on its interior and connectivity as well as customization via apps etc. Differentiation of the car would be primarily via software customization, and less via hardware. Effectively, the hardware would become a commodity. This can be a dangerous setting for established OEMs as, together with the introduction of Industry 4.0, it opens the door to new entrants. If a small, electric, connected pure urban vehicle becomes a "device" like a smartphone and differentiates itself via customization of its software (e.g., all the sides and ceiling in the interior could be covered with flexible displays that could display anything the passengers wanted), then new players will enter the industry. They will produce several hundred thousand identical pure urban vehicles on fully automated assembly lines, using networked robots and other elements of Industry 4.0. Differentiation of products would take place via software with a stringent focus on customer experience in the car. The established players have to move quickly to occupy this space. If not, the story of the iPhone will be repeated and many "Nokias" will see their financials under pressure.

1. Automotive World Market Status

1.1. Production

The automotive industry continued to perform well in 2017, although it grew at a slower pace than in the previous year. Global production of motor vehicles grew by 2.4%, exceeding 97 million units last year. Production growth in the previous period had been 4.6%. The trend was mainly driven by the production of passenger cars, which represent around three-quarters of the total and grew by 1.5% in 2017, slowing down after 5.5% growth in 2016. The remainder corresponded to commercial vehicles, with production increasing by 5.2% after moderate growth of 1.9% the previous year.

World production of passenger cars totaled 73.5 million units last year, which represented a 7.1% increase compared to 2015 and a 53.8% increase compared to the low of 47.8 million in 2009 (OICA, production data 2009 and 2017). The sector performance, however, varies across regions.

Production of passenger cars in the European Union totaled almost 17 million in 2017, posting 0.5% growth in annual terms. Having surpassed the precrisis level of 16.6 million units from 2007, the EU accounted for almost a quarter of global passenger car production in 2017.

Production of passenger cars in the United States declined by 22.6% in annual terms in 2017. However, when trucks, SUVs, pickups and commercial vehicles are also considered, the total production of vehicles declined by only 8.1%. In 2017, US production of commercial vehicles (light and heavy trucks, SUVs, pickups, coaches, and buses) decreased by 1.3%. Pickups in the United States are significant as their use is not commercial alone: many US households use pickups as substitutes for passenger cars (due to their versatility and price point). This should be taken into consideration when comparing the data on passenger compared to commercial vehicles.

Car production in China grew more slowly in 2017 (1.6%) than in 2016 (14.5%). On the other hand, the commercial vehicle segment, which represents 15% of total production, grew by 13.8% in 2017. Overall, total vehicle production in China increased by 3.2%.

As for Japan, after an increase of only 0.8% in 2016, production picked up and increased by 6.0% in 2017. Overall, total vehicle production in Japan increased by 5.3%, above the global average (OICA, production data).

Regarding emerging markets, India continued to grow in 2016, posting a 5.8% annual rise in total vehicle production. In contrast, Mexico's vehicle production grew by 13%, mainly driven by significant growth of 35% in the commercial vehicle segment, which represents more than half of the country's production. Brazil is experiencing a significant recovery, with total vehicle production increasing by 25.2% in 2017 and surpassing Canada. Nevertheless, total output was still 27.3% lower than the precrisis 2013 figures (OICA, production data).

As of the end of 2017, China continued to lead the ranking of car manufacturing countries, a position it has held without interruption since 2009. The United States occupied second place, followed by Japan, Germany and India (OICA, production data).

Later sections of this document will follow OICA classifications to define the different segments in the auto manufacturing industry. The only exception will be the United States, where a slightly different definition will be used. The following are the main segments in the auto manufacturing industry:

- **Passenger cars** are motor vehicles with at least four wheels, used for the transport of passengers, and comprising no more than eight seats in addition to the driver's seat.
- **Light commercial vehicles** (also referred as light-duty vehicles) are motor vehicles with at least four wheels, used for the carriage of goods. The mass given in metric tons is used as a limit between light commercial vehicles and heavy trucks. This limit depends on national and professional definitions and varies between 3.5 and 7 tons.
- **Heavy trucks** are vehicles intended for the carriage of goods. The maximum authorized mass is over the limit of light commercial vehicles (7 tons). They include tractor vehicles designed for towing semitrailers ("semis").
- **Buses and coaches** are used for the transport of passengers, having more than eight seats in addition to the driver's seat as well as a maximum mass over the limit of light commercial vehicles (7 tons).

It is also worth clarifying the following terms:

- **Light vehicles** include passenger cars and light commercial vehicles.
- **Heavy-duty vehicles** include heavy trucks, buses and coaches.
- **Commercial vehicles** include light commercial vehicles, heavy trucks, coaches and buses.
- **Total motor vehicles** include all passenger cars and commercial vehicles.

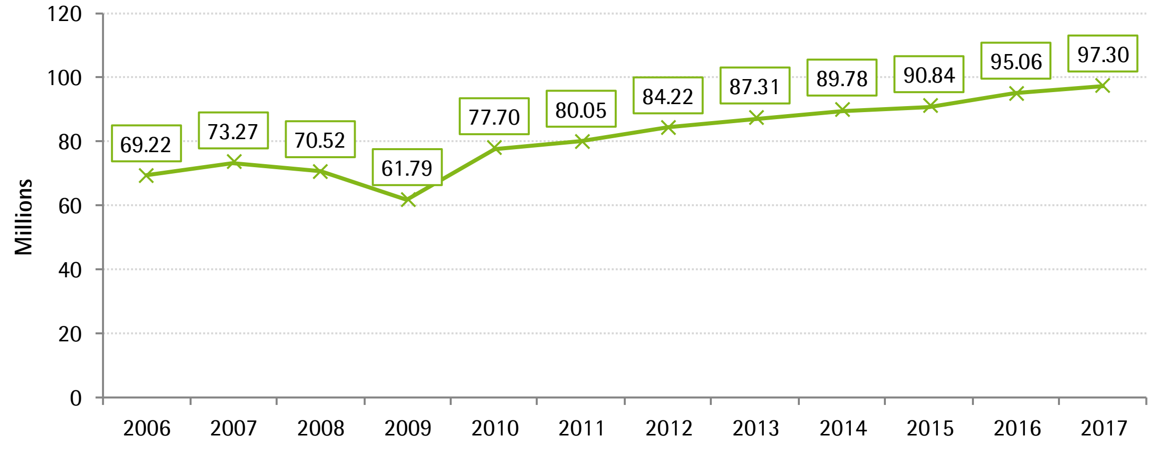
Production data was obtained from the OICA (International Organization of Motor Vehicle Manufacturers) website and could differ from the production data published by some of the manufacturers in their annual reports. Possible reasons for any divergence are:

a) the consideration of vehicles produced by the OEM for other manufacturers—for example, Toyota does not count its production of the Malaysian brand Perodua as its own. However, the Japan Automobile Manufacturers Association sees it that way and reports those numbers to OICA; and

b) differences in methodology—for example, there is no uniform distinction between produced and delivered units across all manufacturers. For this report, the production data for all volume manufacturers are derived from OICA (latest data available: 2017). Production data for the premium segment were extracted from annual reports (latest data available: 2017).

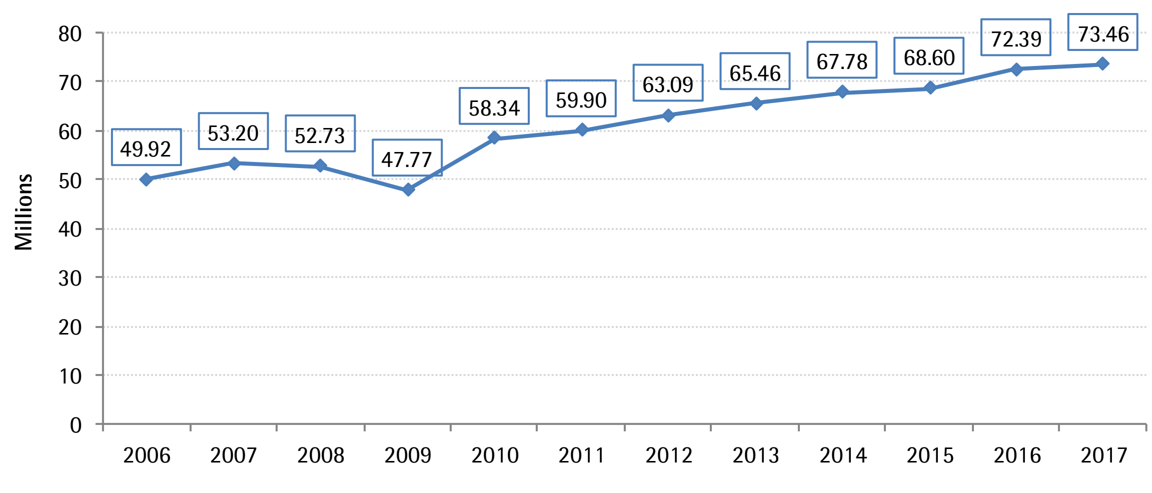
1.1.1. Worldwide Production by Segment

Figure 3
Total Motor Vehicles Produced Worldwide



Source: OICA, Production Data.

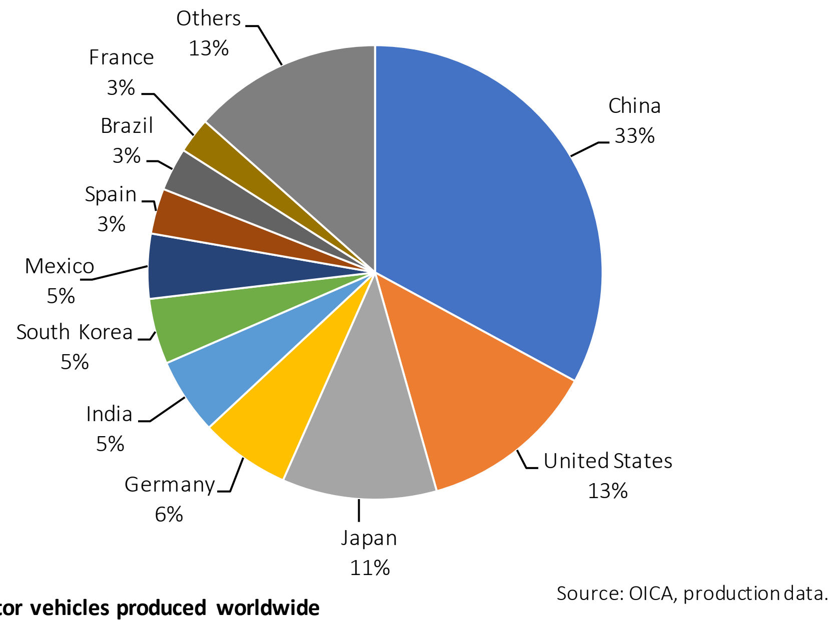
Figure 4
Total Passenger Cars Produced Worldwide



Source: OICA, production data.

1.1.2. Top Manufacturing Countries

Figure 5
Top 10 Manufacturing Countries in the Automotive Industry in 2017



Total motor vehicles produced worldwide in 2017: 97,302,534

Figure 6
Top Manufacturing Regions in the Automotive Industry in 2017

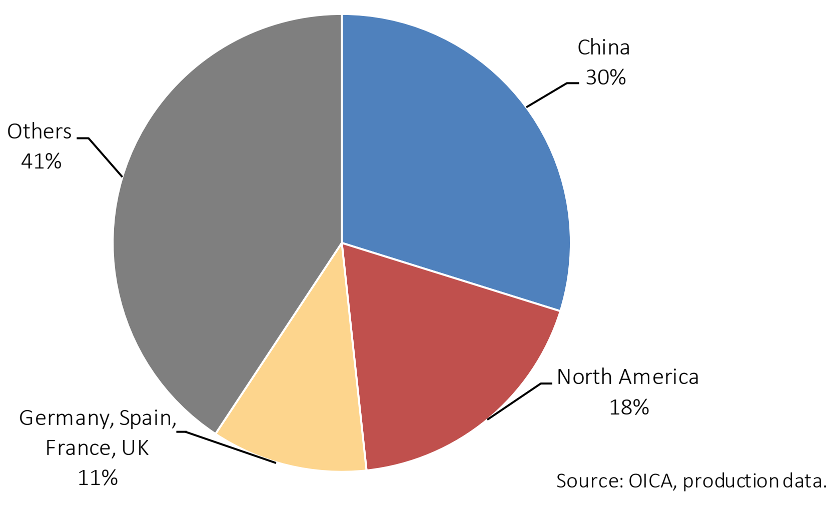
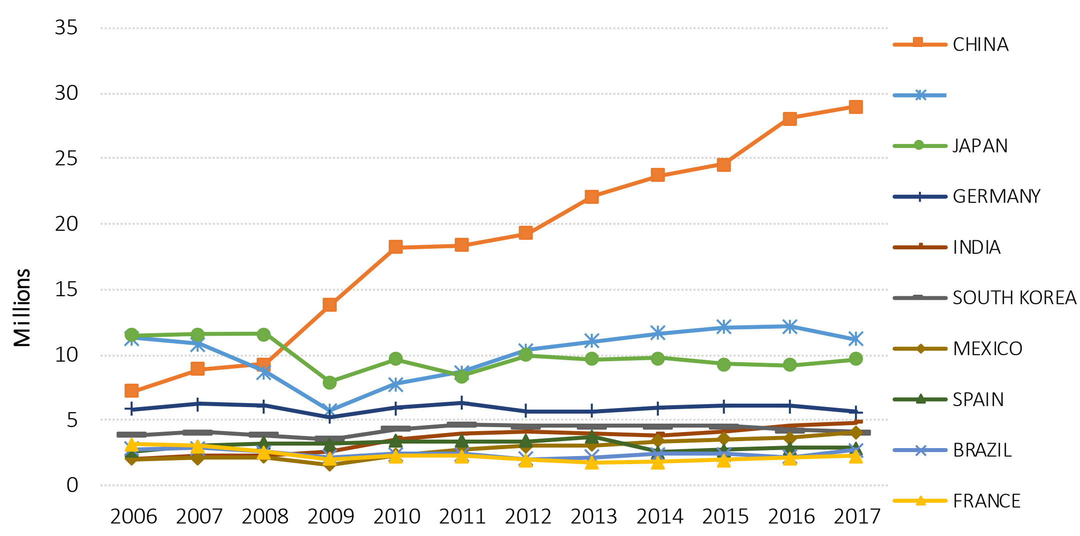
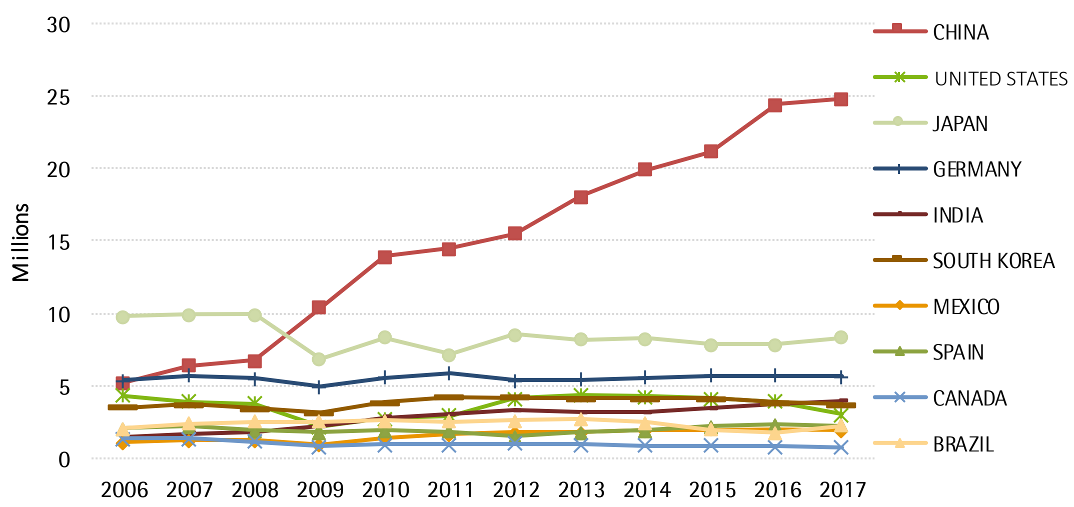


Figure 7
Top 10 Manufacturing Countries: Total Motor Vehicles Produced



Source: OICA, production data.

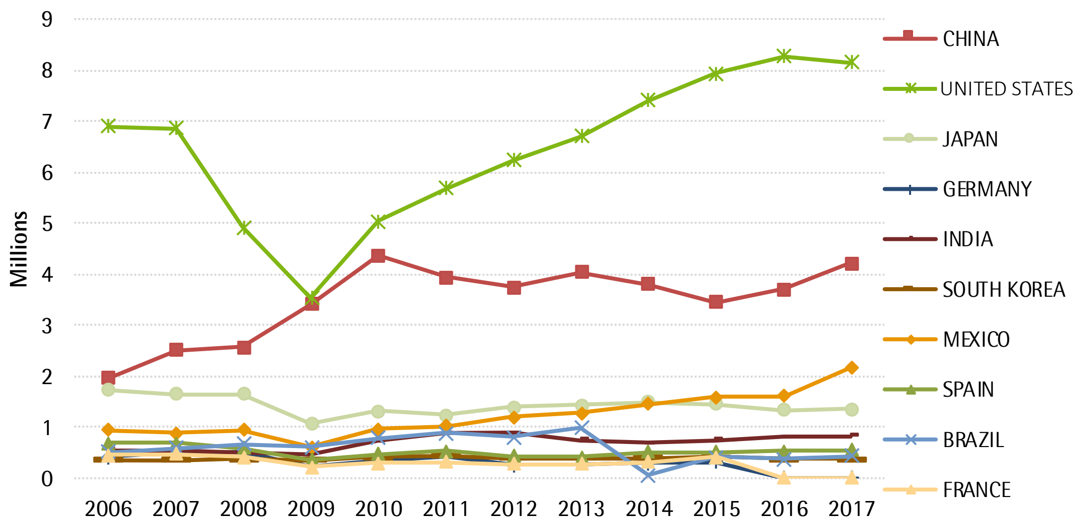
Figure 8
Top 10 Manufacturing Countries: Total Passenger Cars Produced



Source: OICA, production data.

Figure 9

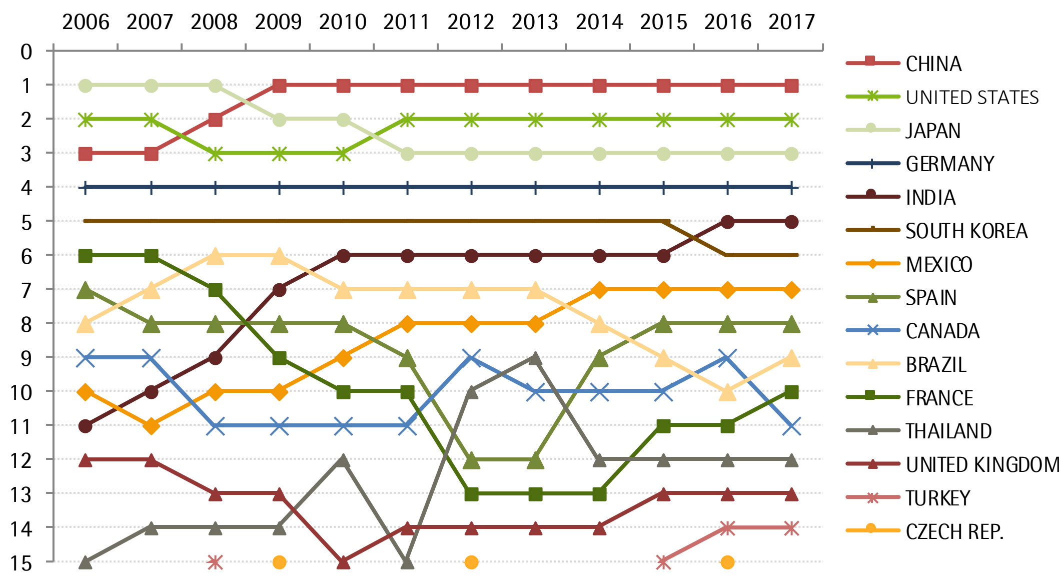
Top 10 Manufacturing Countries: Total Commercial Vehicles Produced



Source: OICA, production data.

Figure 10

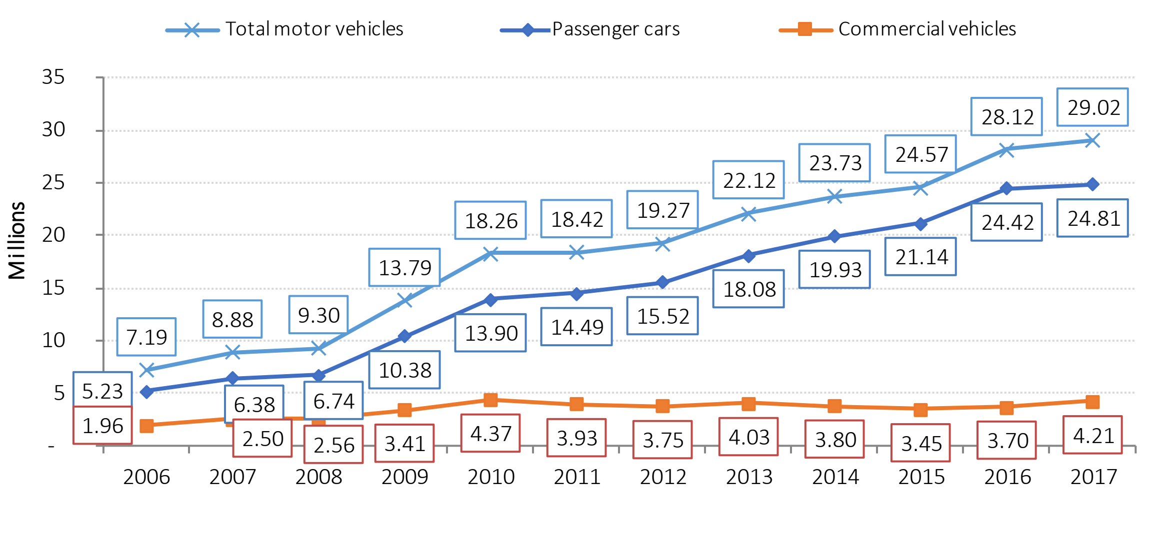
Countries' Production Ranking. (Total Motor Vehicles)



Source: OICA, production data.

1.1.2.1. Annual Production by Segment (Units): China

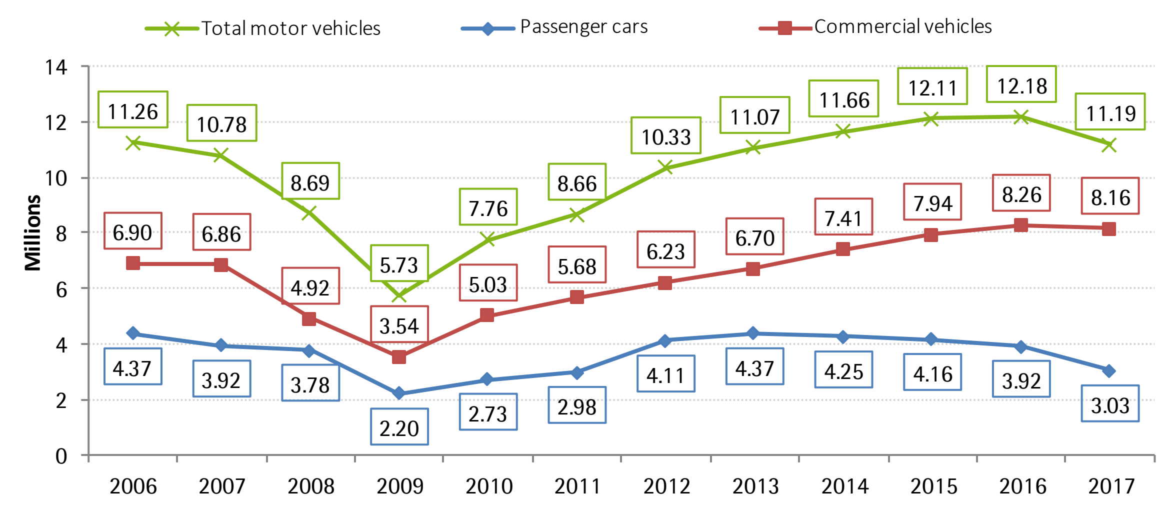
Figure 11
China: Production Statistics



Source: OICA, production data.

1.1.2.2. Annual Production by Segment (Units): United States

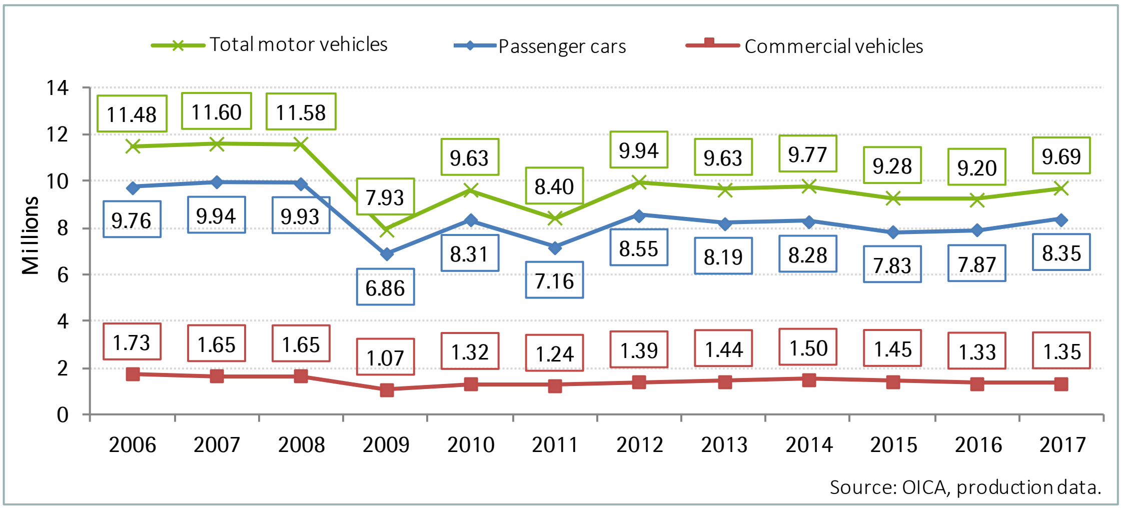
Figure 12
United States: Production Statistics



Source: OICA, production data.

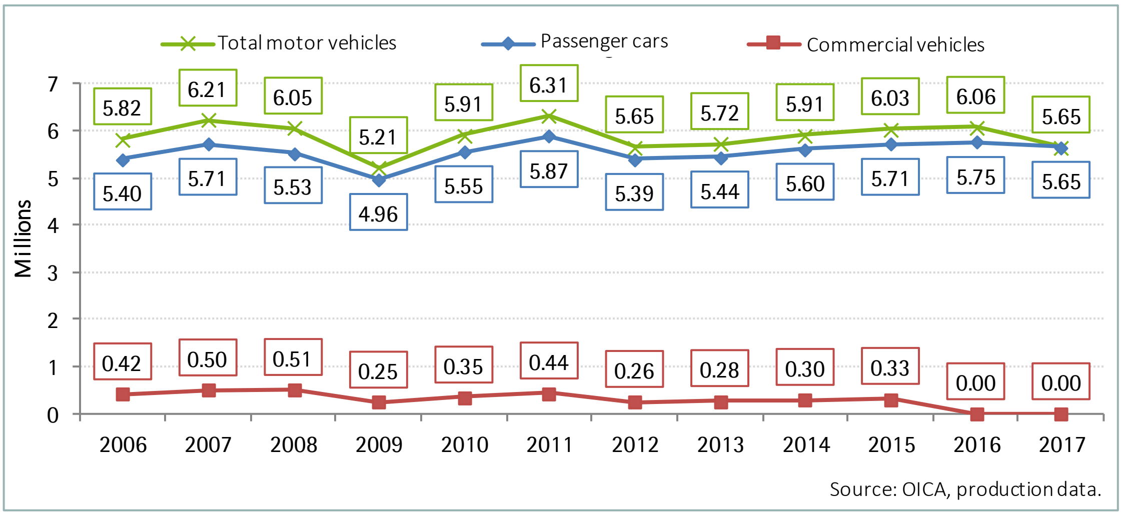
1.1.2.3. Annual Production by Segment (Units): Japan

Figure 13
Japan: Production Statistics



1.1.2.4. Annual Production by Segment (Units): Germany

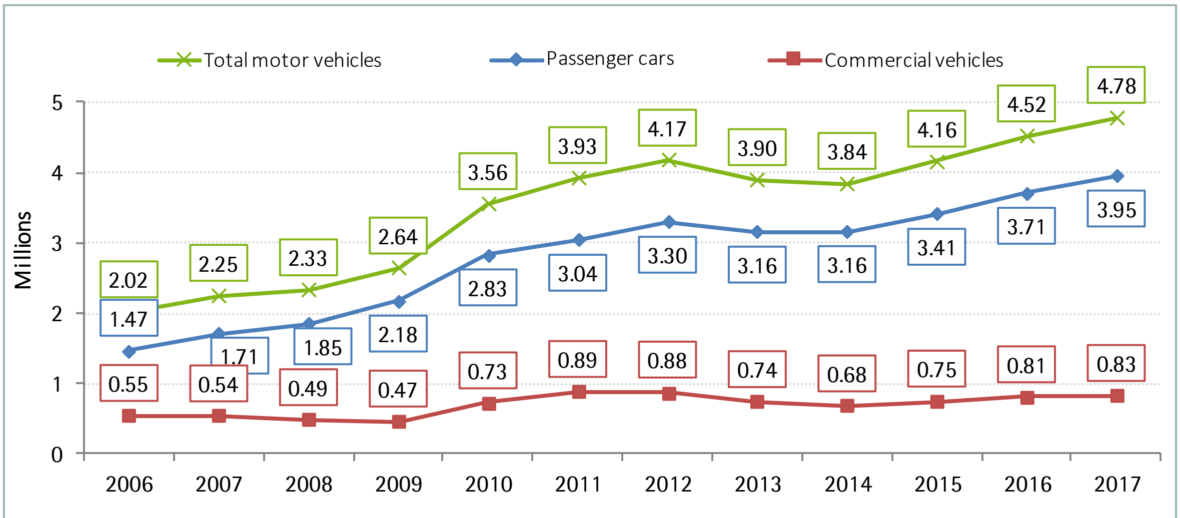
Figure 14
Germany: Production Statistics



In 2017, commercial vehicles of more than 6 tons had a total market volume of about 356,000 in Europe but the available data do not break down production by country.

1.1.2.5. Annual Production by Segment (Units): India

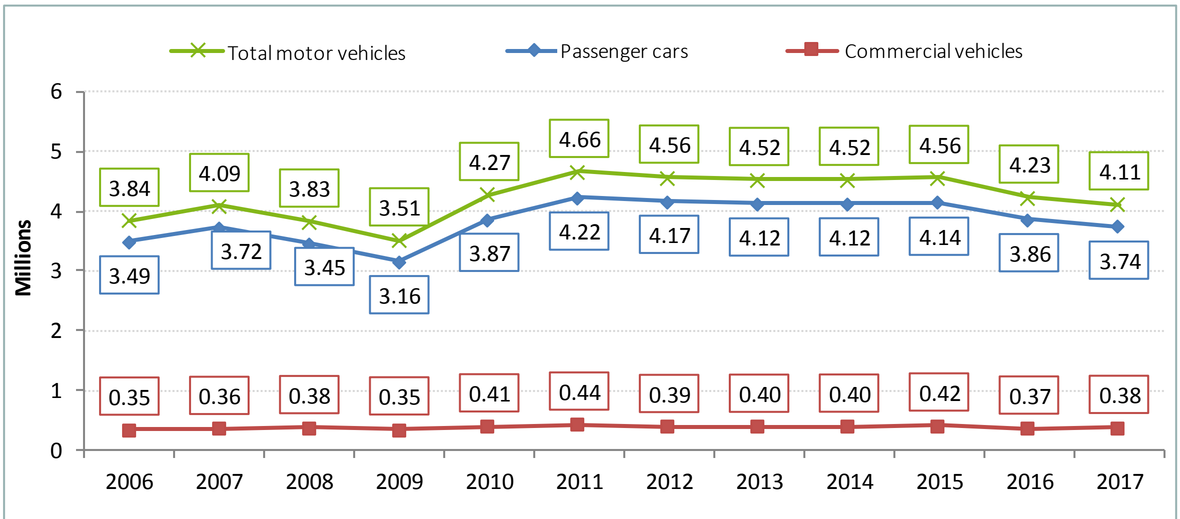
Figure 15
India: Production Statistics



Source: OICA, production data.

1.1.2.6. Annual Production by Segment (Units): South Korea

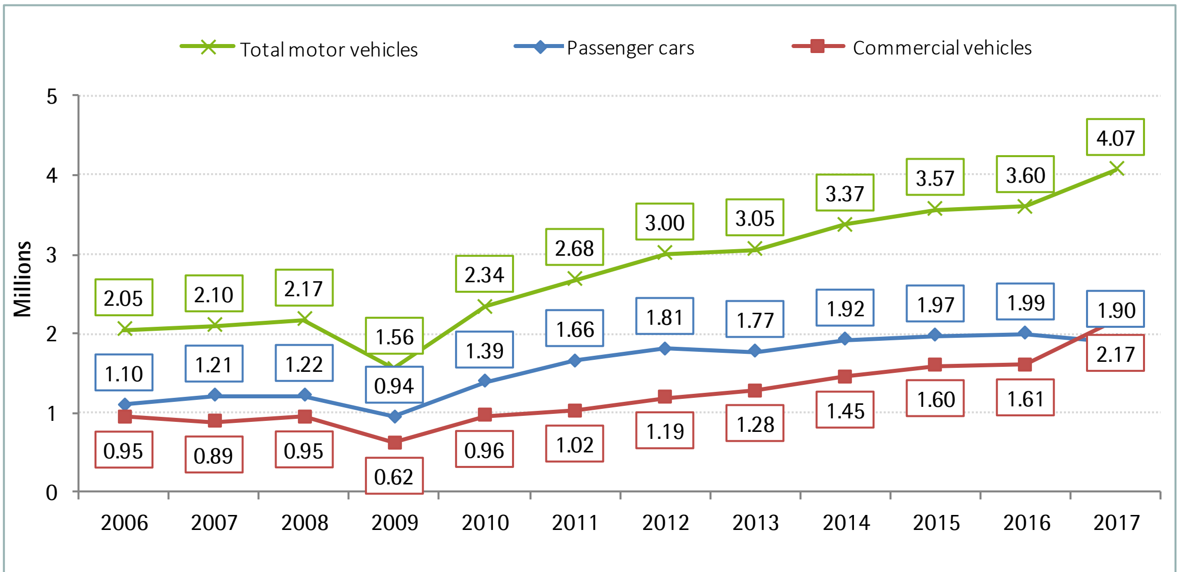
Figure 16
South Korea: Production Statistics



Source: OICA, production data.

1.1.2.7. Annual Production by Segment (Units): Mexico

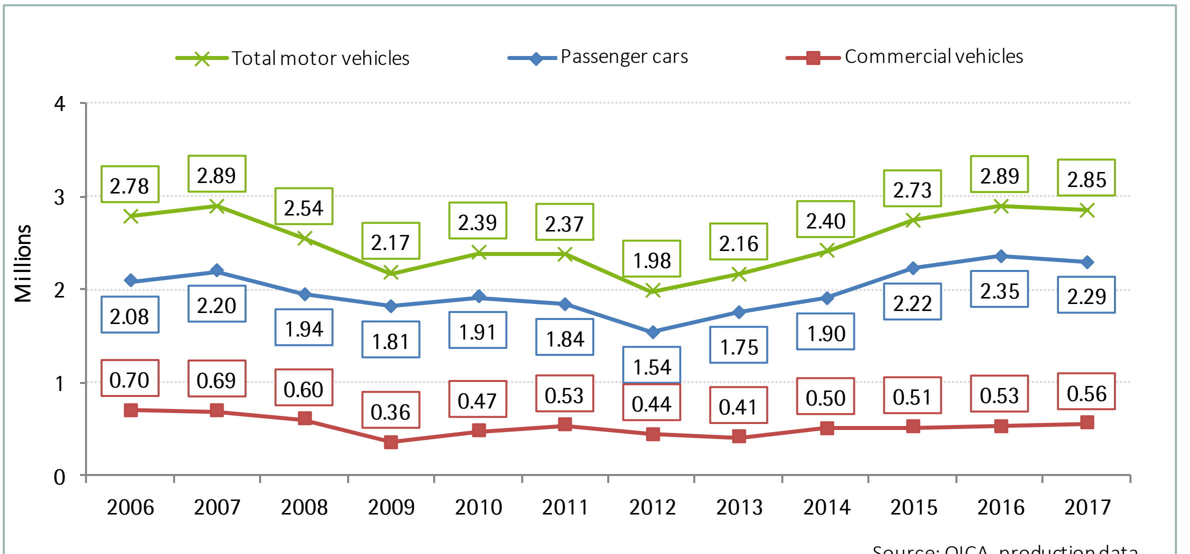
Figure 17
Mexico: Production Statistics



Source: OICA, production data.

1.1.2.8. Annual Production by Segment (Units): Spain

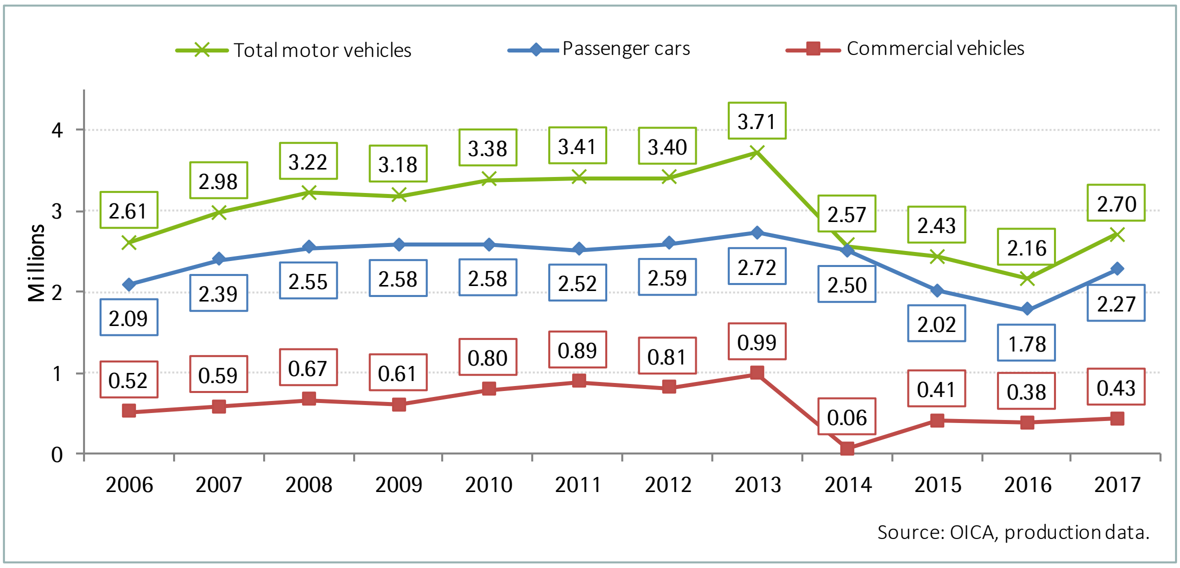
Figure 18
Spain: Production Statistics



Source: OICA, production data.

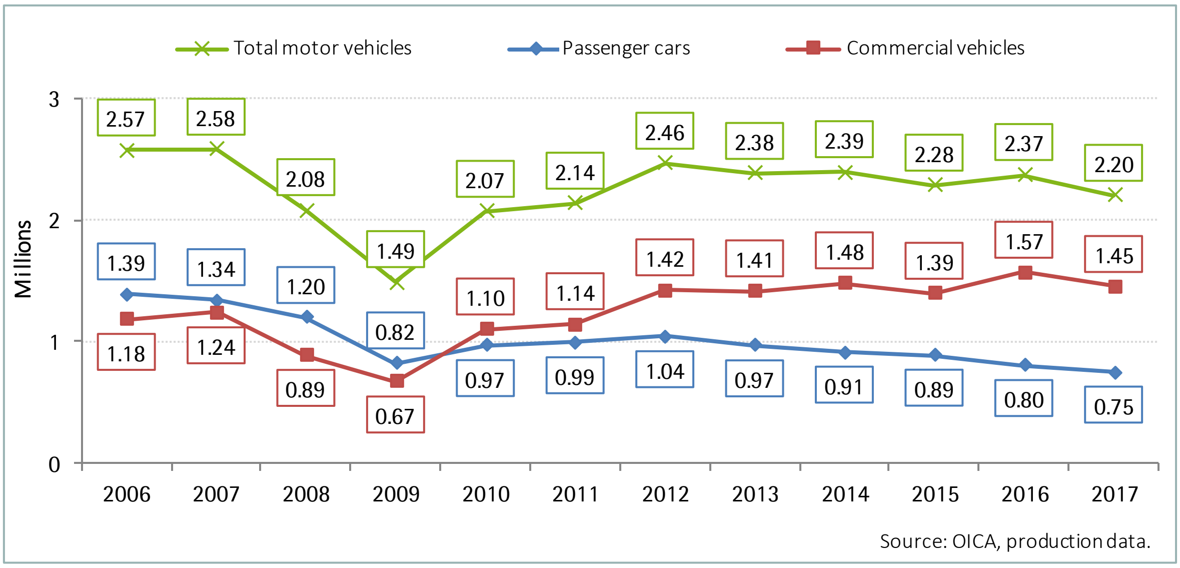
1.1.2.9. Annual Production by Segment (Units): Brazil

Figure 19
Brazil: Production Statistics



1.1.2.10. Annual Production by Segment (Units): Canada

Figure 20
Canada: Production Statistics



1.1.3. Top Manufacturers

Automotive manufacturers are in a constant battle to outsell their competitors. In part the motivation for this can be found in the economies of scale in the industry, which were first studied in detail by Maxcy and Silberston in 1959.[30] However, a more recent study has questioned the presence of economies of scale beyond the plant level.[31] It therefore seems astonishing that OEMs are so focused on production and sales data, rather than profitability.

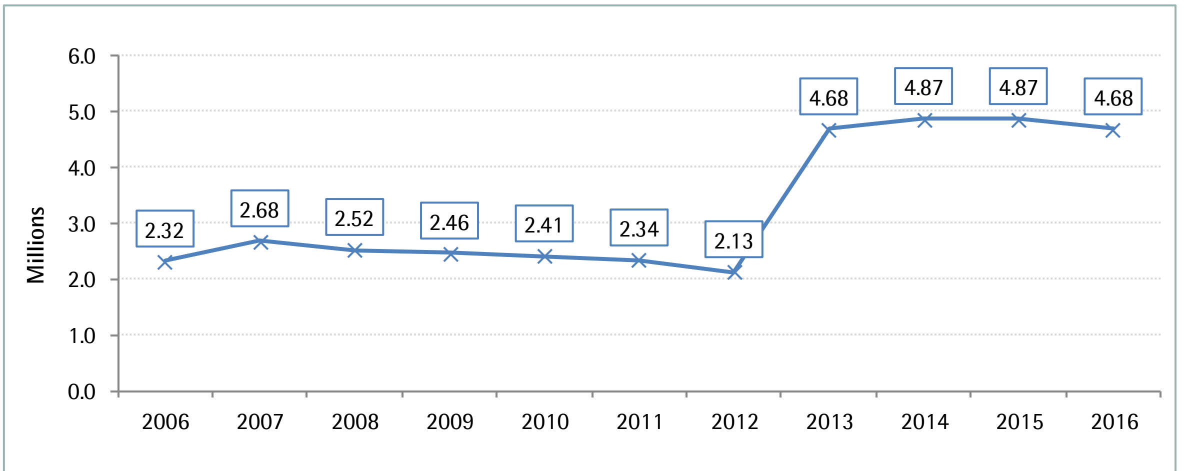
1.1.3.1. Volume Segment

Companies in the volume segment offer value-for-money vehicles and represent the largest OEM groups, including Volkswagen, Toyota, Renault-Nissan, GM, and Hyundai-Kia. Product sold in this segment typically generate low margins, and OEMs have to produce large volumes to generate large absolute margins.

1.1.3.1.1. Fiat Chrysler Automobiles (FCA)

The data include the Abarth, Alfa Romeo, Chrysler, Dodge, Fiat, Fiat Professional, Jeep, Lancia and Ram brands, as well as Iveco and Pegaso (heavy commercial vehicles and buses), Tofaş (Turkey), Yuejin, Power Daily and SIH (China). The data also include the luxury car brands Maserati and Ferrari. (Note that in Ferrari was separated from FCA in an IPO in 2015.)

Figure 21
Total Units Produced: FCA



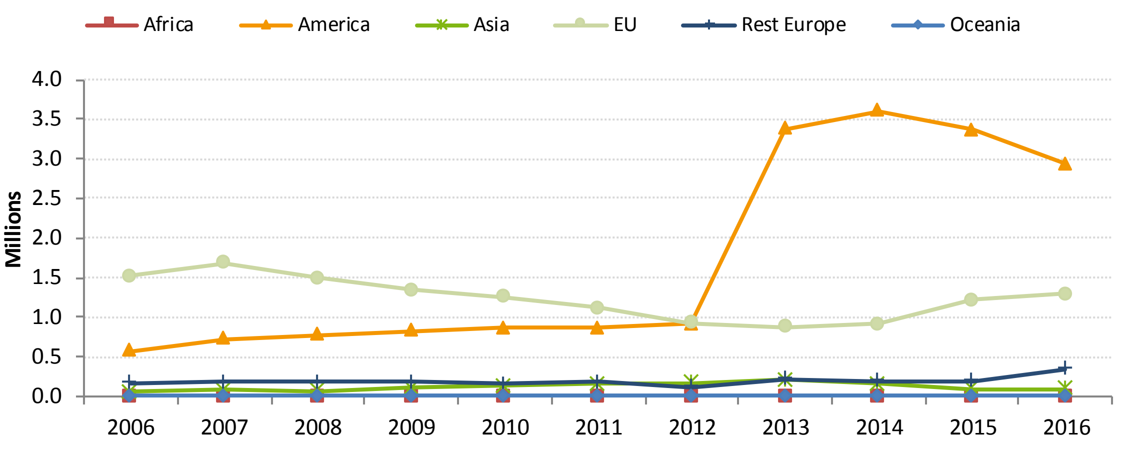
Source: OICA, production data.

Note: Chrysler became a subsidiary of Fiat Chrysler Automobiles (FCA) in 2014.

[30] George Maxcy and Aubrey Silberston, *The Motor Industry* (London: Allen & Unwin, 1959).

[31] Max Warburton, Abbas Ali Quettawala, Robin Zhu, and Bo Wen, "VW: MQB Benefits Are Over-hyped – The Economies of Scale Do Not Support Some of the More Outlandish Claims," Bernstein Research, March 26, 2013.

Figure 22
Total Produced by Region: FCA

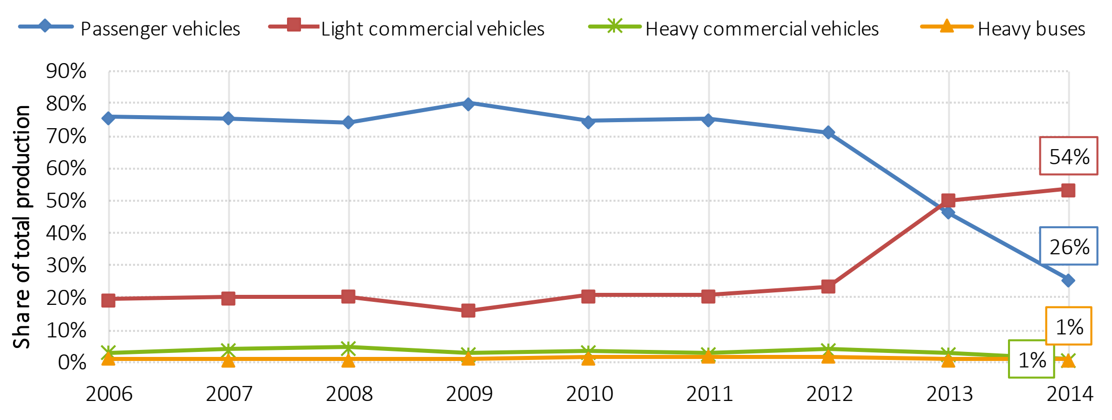


Rest Europe: Serbia, Turkey

Source: OICA, production data.

Note: Chrysler became a subsidiary of Fiat Chrysler Automobiles (FCA) in 2014.

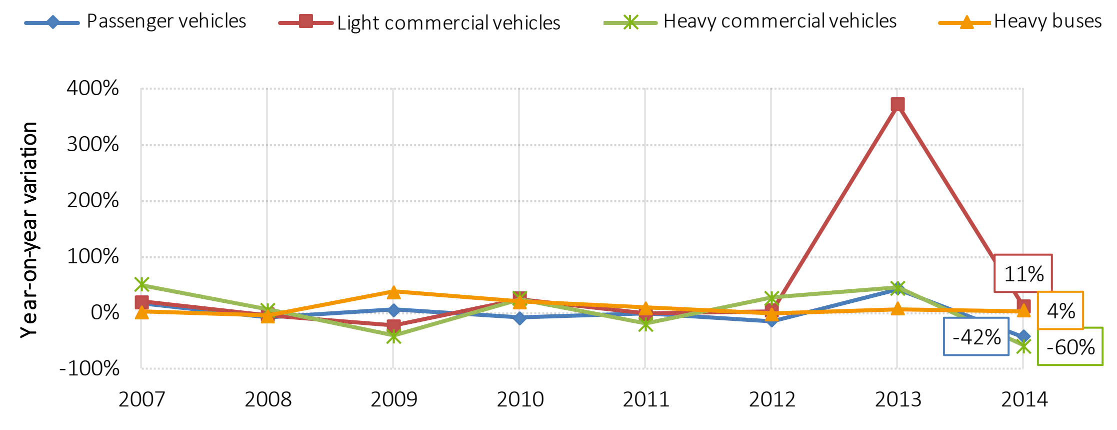
Figure 23
Production by Vehicle Type: FCA



Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

Figure 24
Production by Vehicle Type: FCA

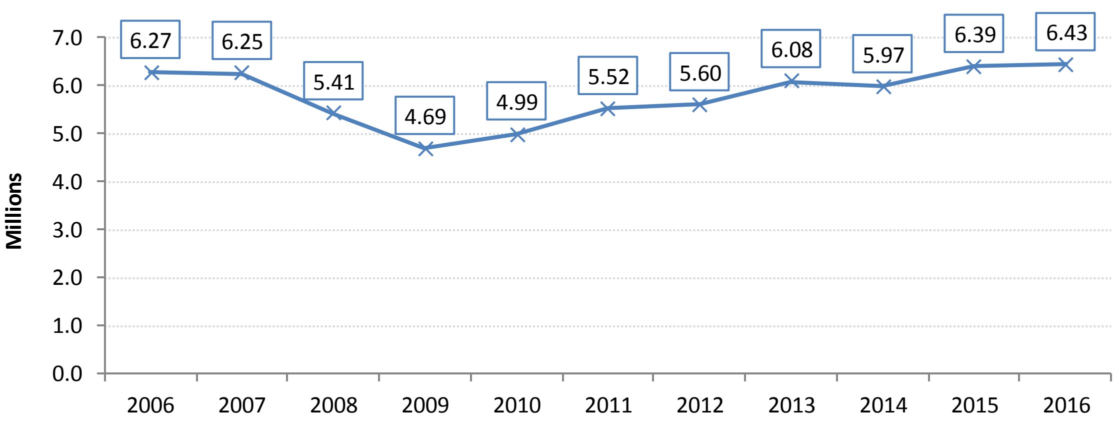


Source: OICA, production data.

1.1.3.1.2. Ford Motors

The data include Ford, Lincoln and Troller, as well as Aston Martin (until 2007), Mercury (until 2011), Jaguar and Land Rover (until 2008), Volvo (until 2010), Mazda (until 2015), and FPV (until 2014). In April 2018, Ford announced that, by 2022, the company would not sell any sedans in North America (with the exception of the Ford Mustang and Focus Active), focusing on vans and pickups instead.

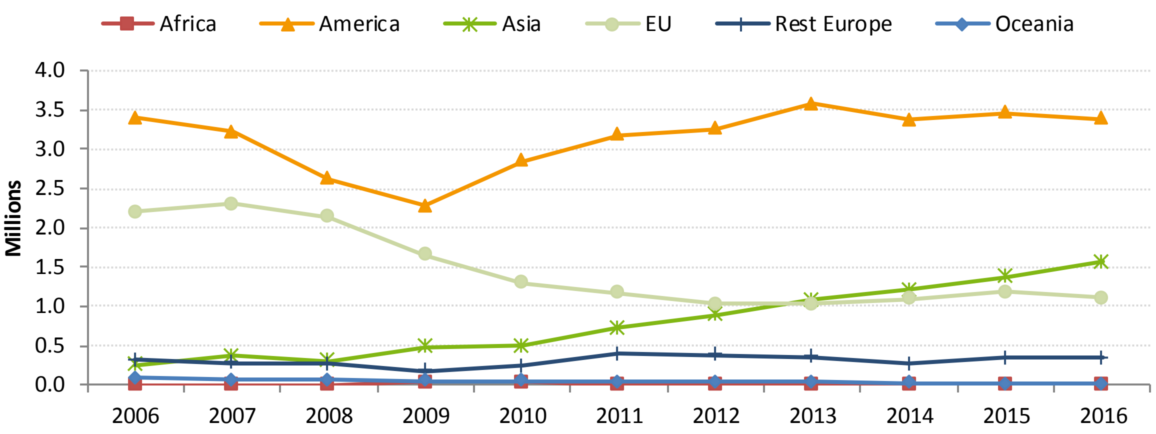
Figure 25
Total Units Produced: Ford



Source: OICA, production data.

Figure 26

Total Produced by Region: Ford

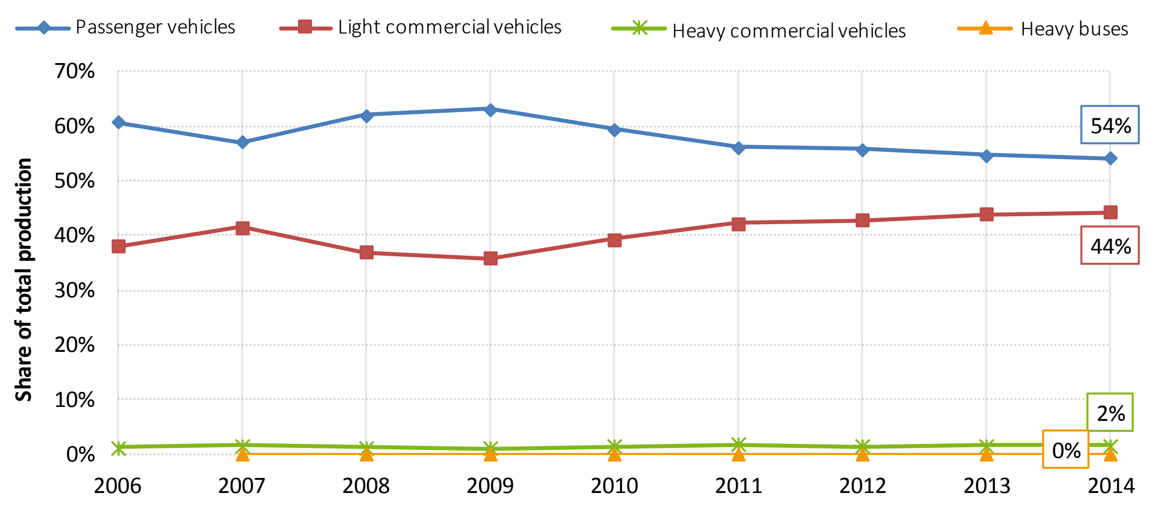


Rest Europe: Russia, Turkey

Source: OICA, production data.

Figure 27

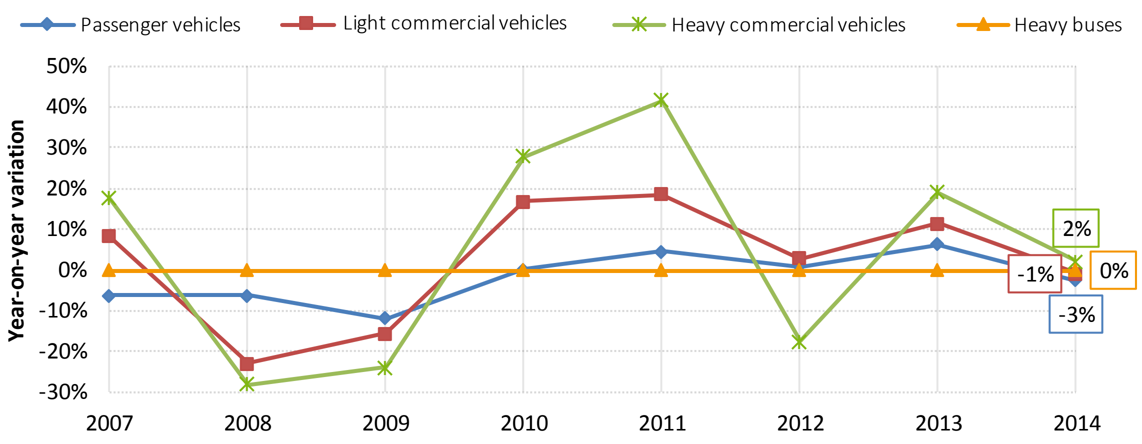
Production by Vehicle Type: Ford



Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

Figure 28
Production by Vehicle Type: Ford



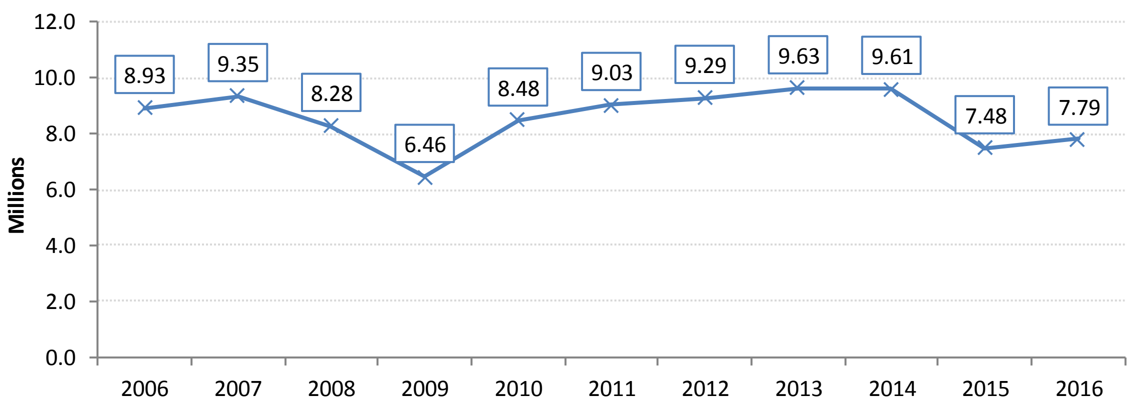
Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

1.1.3.1.3. General Motors

As it emerged from bankruptcy in 2010, General Motors (GM) reorganized the content and structure of its brand portfolio. Some brands were discontinued or sold, such as Pontiac, Saturn, Saab, Hummer, and Goodwrench. Today, General Motors comprises the US brands Buick, Cadillac, Chevrolet, and GMC, as well as Holden (Australia), and Baojun, Jiefang, and Wuling (China). Opel (Germany) and Vauxhall (United Kingdom) were sold to the PSA Group in 2017.

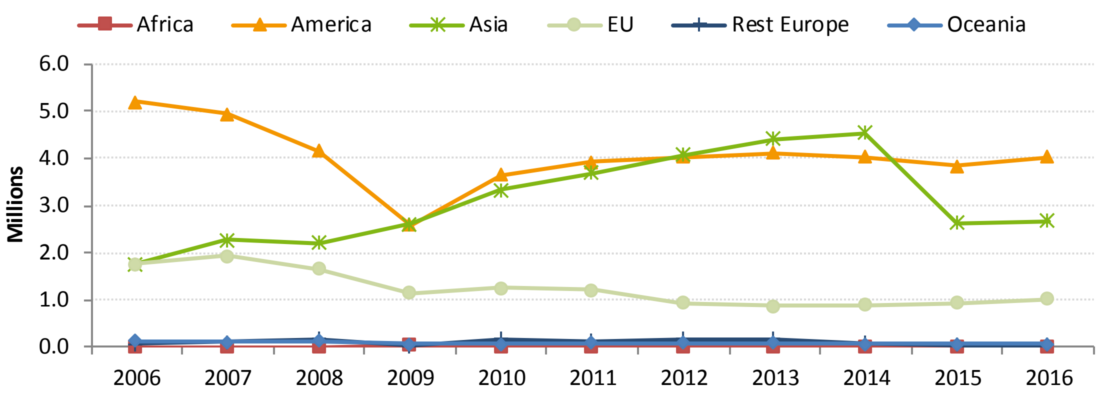
Figure 29
Total Units Produced: GM



Source: OICA, production data.

Figure 30

Total Produced by Region: GM



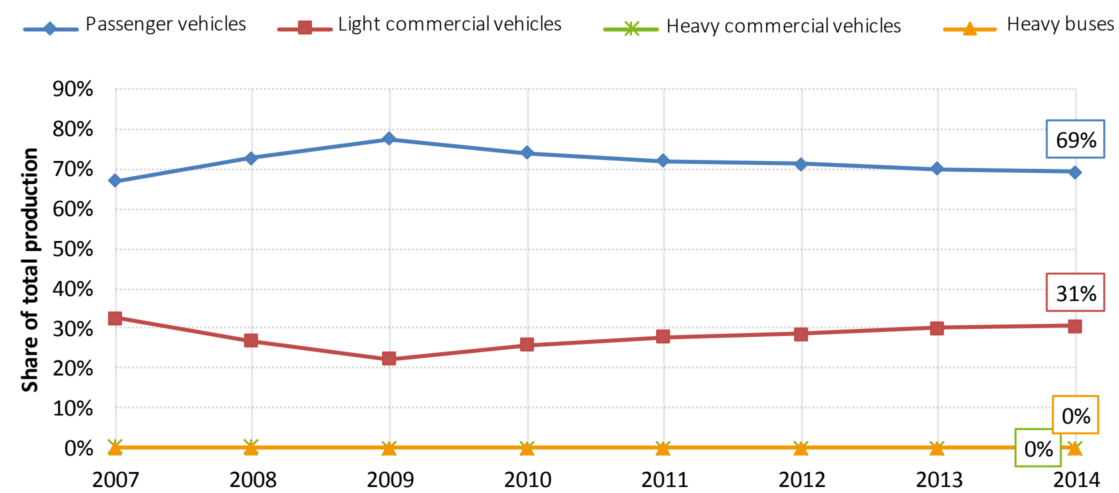
Rest Europe: Russia, Turkey

Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

Figure 31

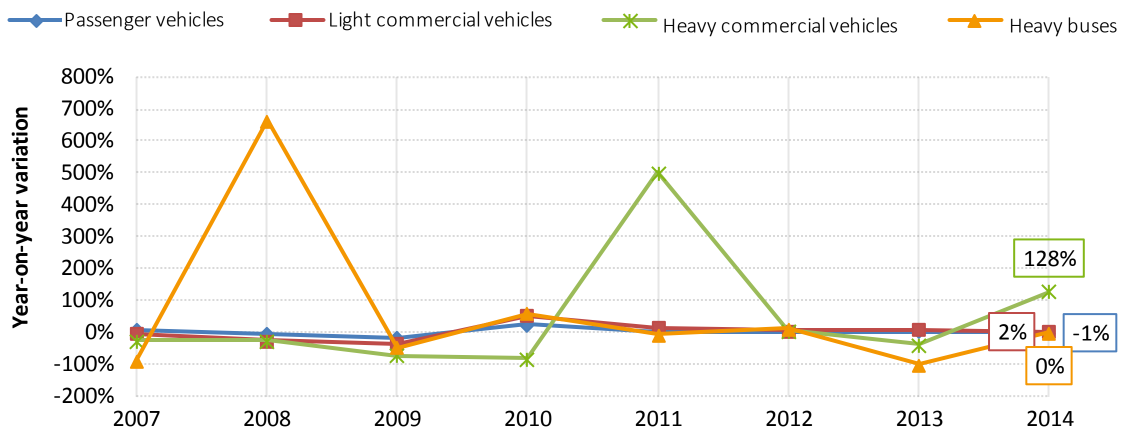
Production by Vehicle Type: GM



Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

Figure 32
Production by Vehicle Type: GM



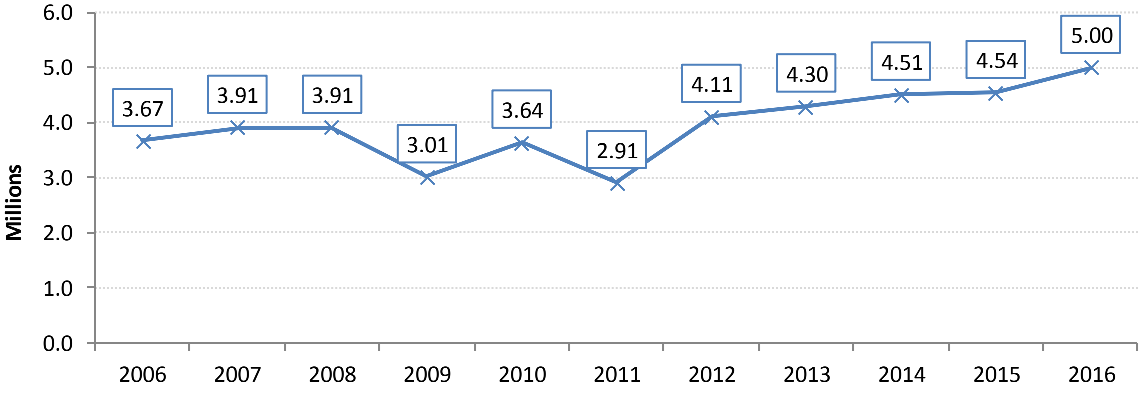
Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

1.1.3.1.4. Honda

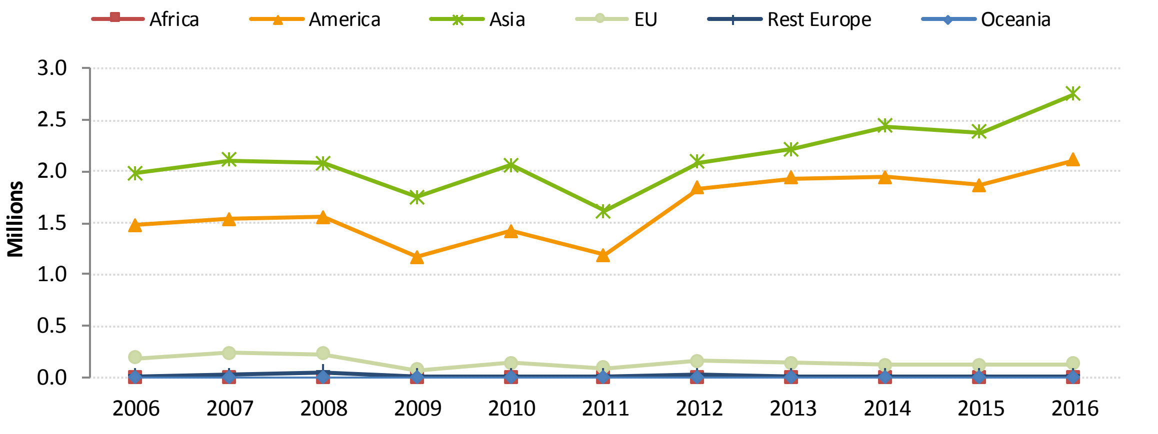
The automobile brands include Honda and the premium brand Acura.

Figure 33
Total Units Produced: Honda



Source: OICA, production data.

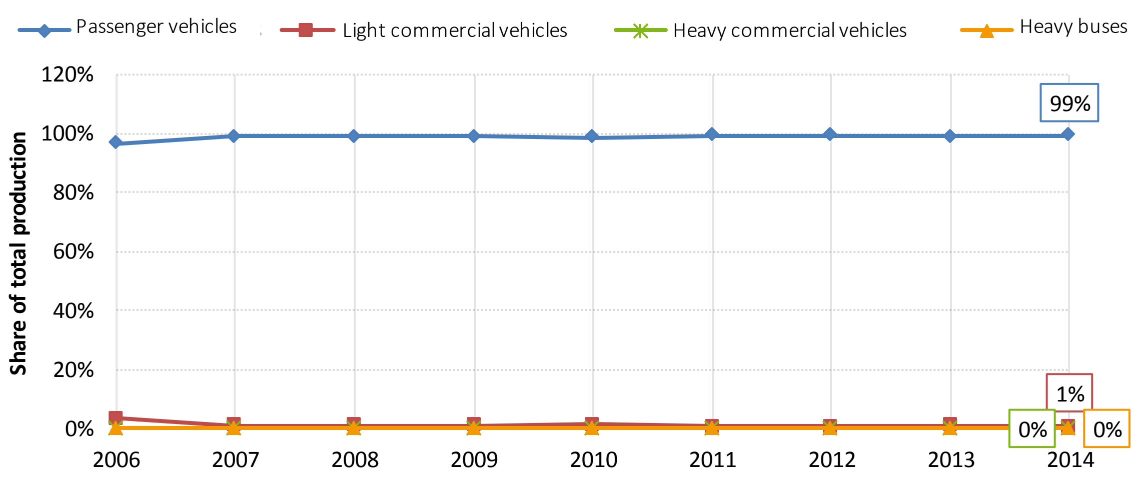
Figure 34
Total Produced by Region: Honda



Rest Europe: Russia, Turkey

Source: OICA, production data.

Figure 35
Production by Vehicle Type: Honda

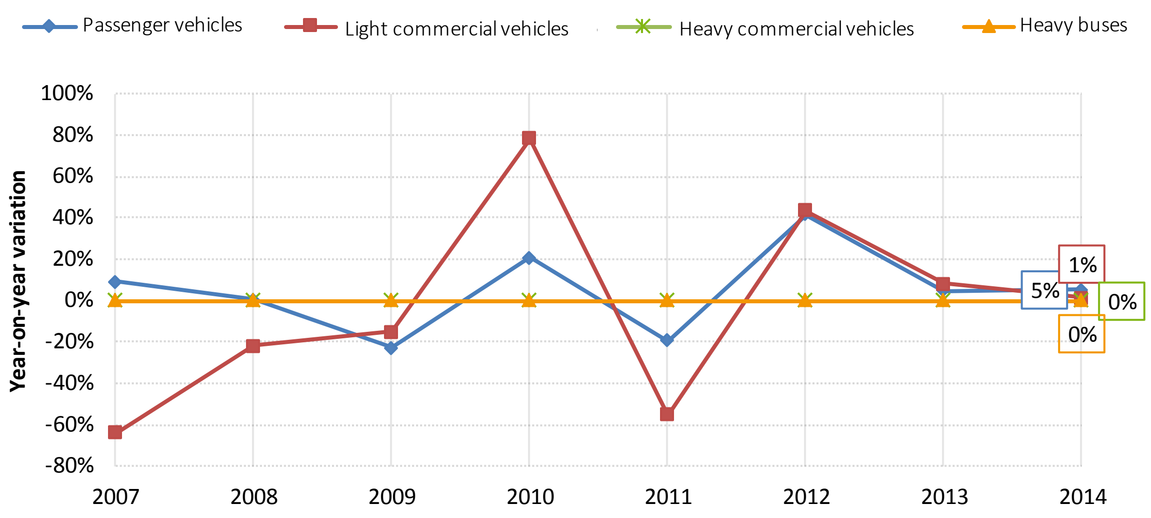


Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

Figure 36

Production by Vehicle Type: Honda



Source: OICA, production data.

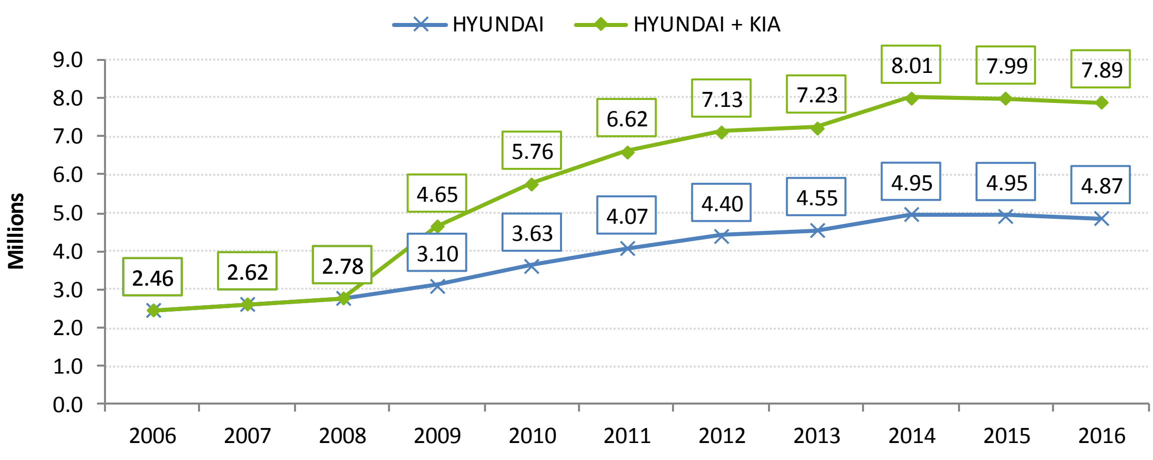
Note: Vehicle type was not specified in the 2015–16 data.

1.1.3.1.5. Hyundai Motor Group

The automobile brands include Hyundai, Genesis, and Kia.

Figure 37

Total Units Produced: Hyundai



Source: OICA, production data.

Figure 38
Total Produced by Region: Hyundai

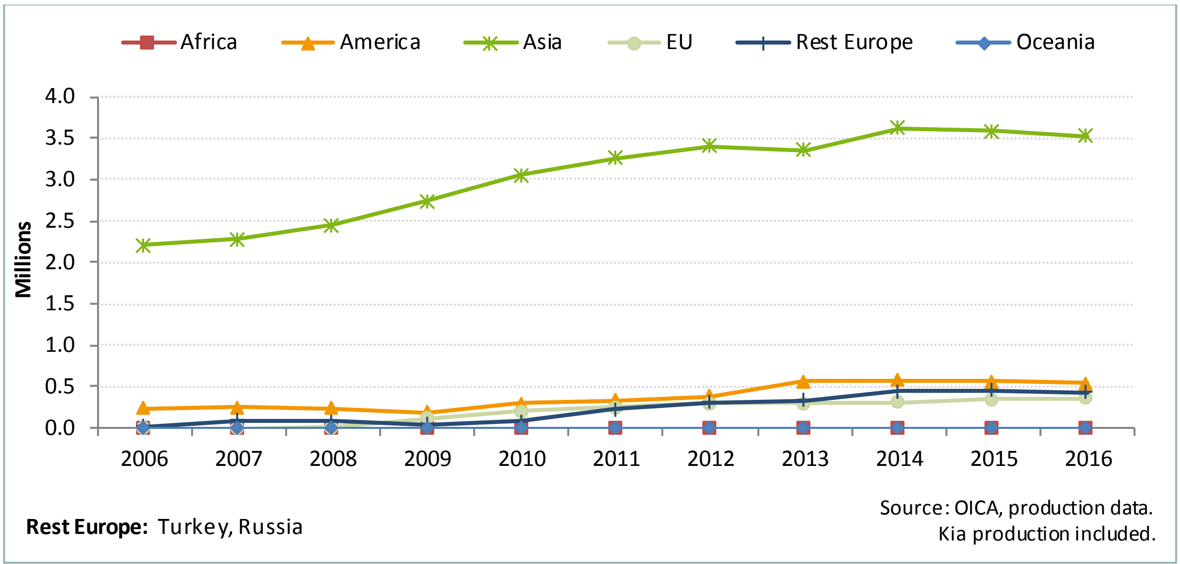


Figure 39
Production by Vehicle Type: Hyundai

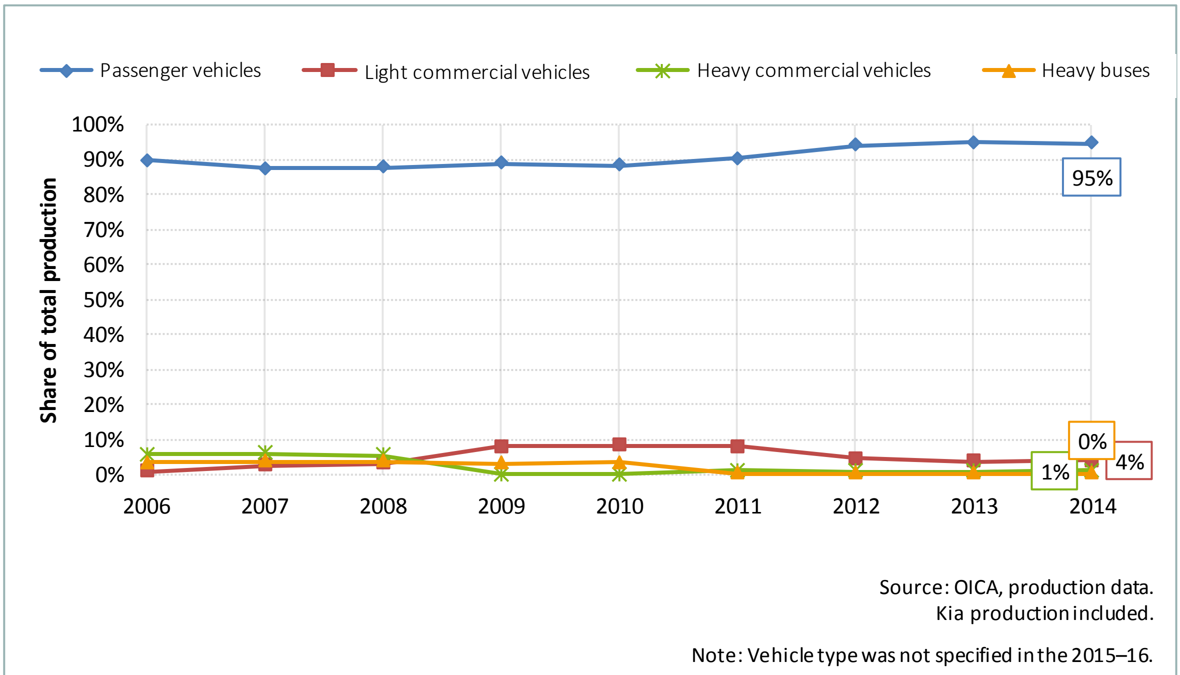
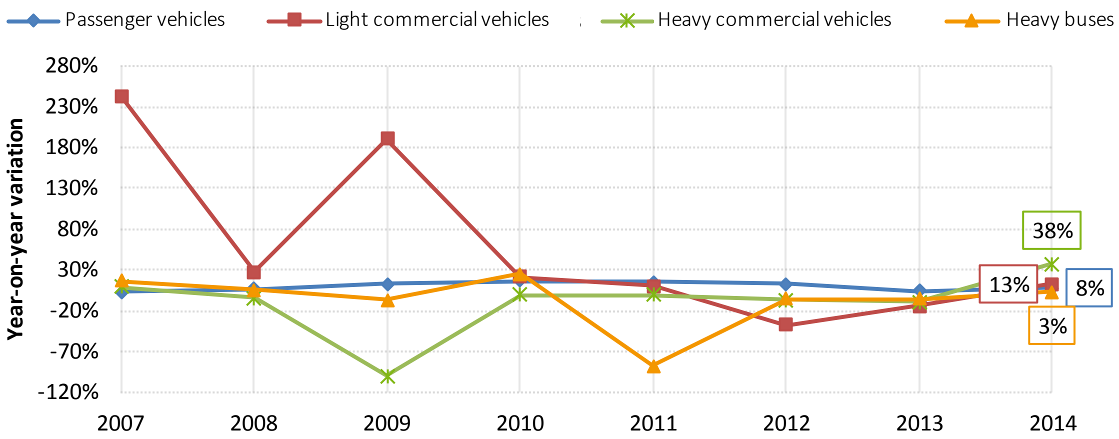


Figure 40
Production by Vehicle Type: Hyundai



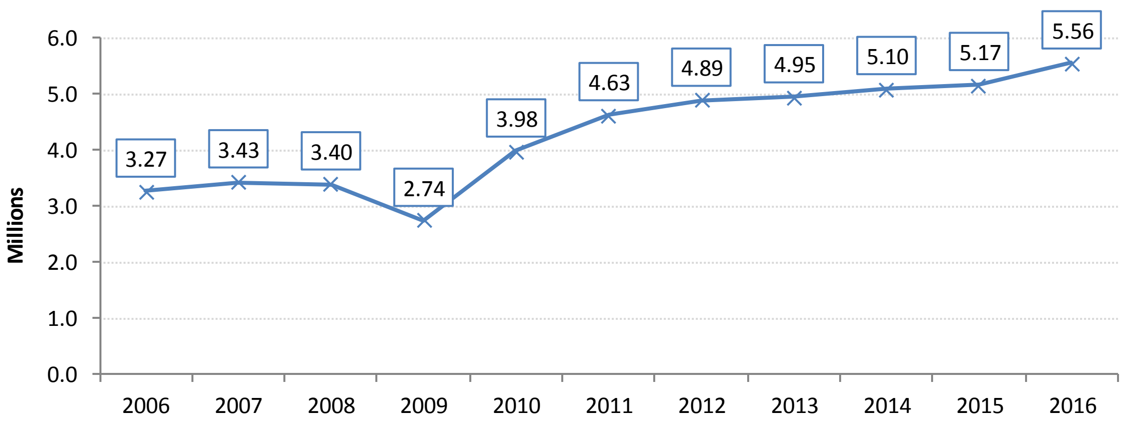
Source: OICA, production data.
Kia production included.

Note: Vehicle type was not specified in the 2015–16 data.

1.1.3.1.6. Nissan Motor Company

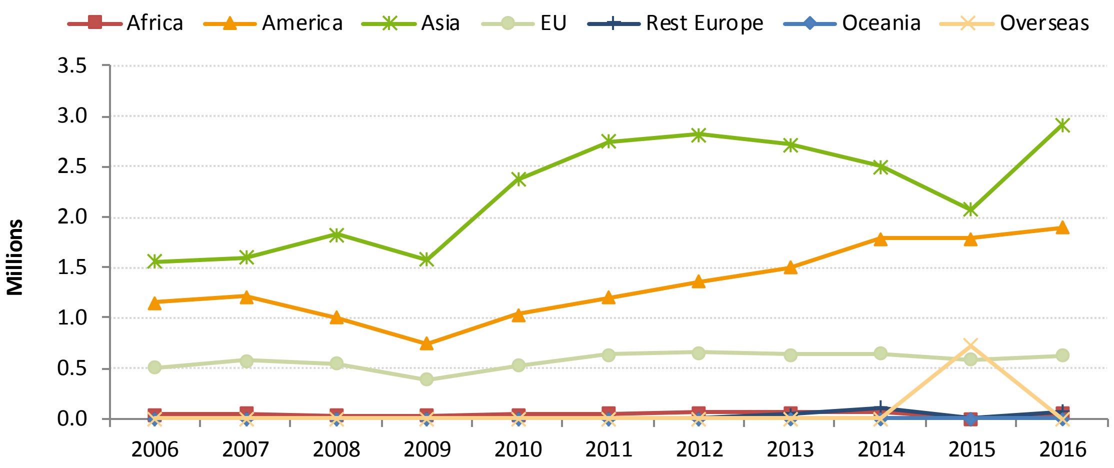
The Nissan Motor Company produces cars under the Nissan, Infiniti, and Datsun brands.

Figure 41
Total Units Produced: Nissan



Source: OICA, production data.

Figure 42
Total Produced by Region: Nissan

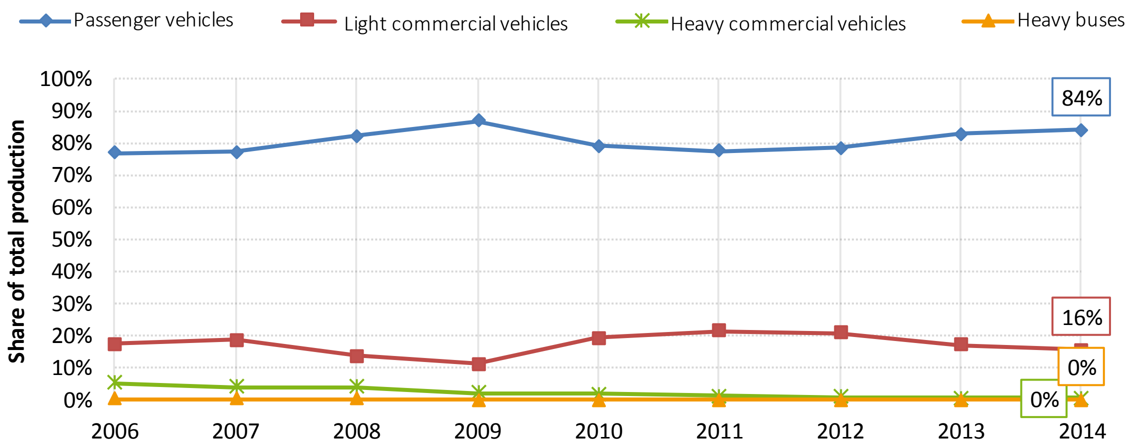


Source: OICA, production data.

Rest Europe: Russia, Turkey
Africa: South Africa, Egypt. **Overseas:** not specified

Note: The counting methodology changed in 2015: some Asian countries were included in "overseas."

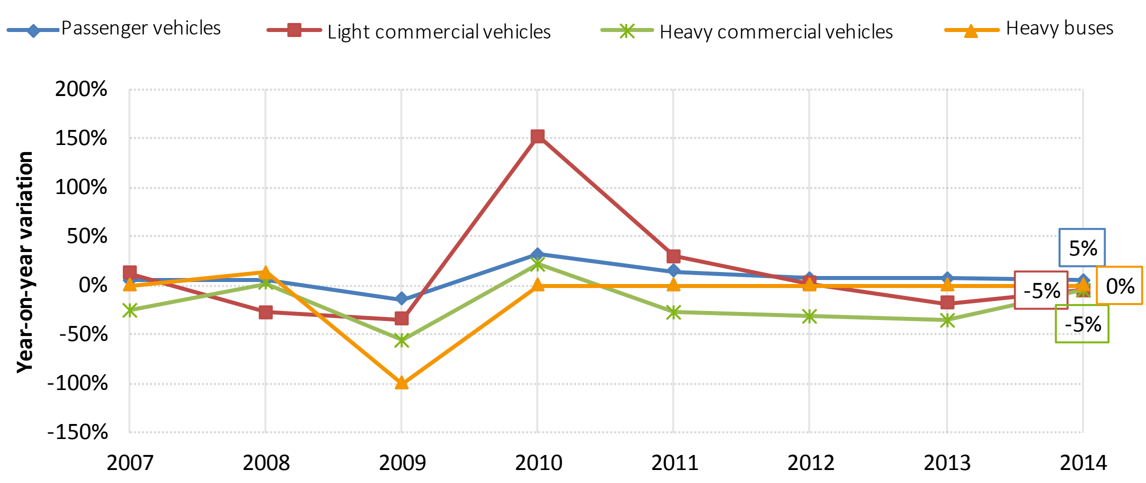
Figure 43
Production by Vehicle Type: Nissan



Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

Figure 44
Production by Vehicle Type: Nissan



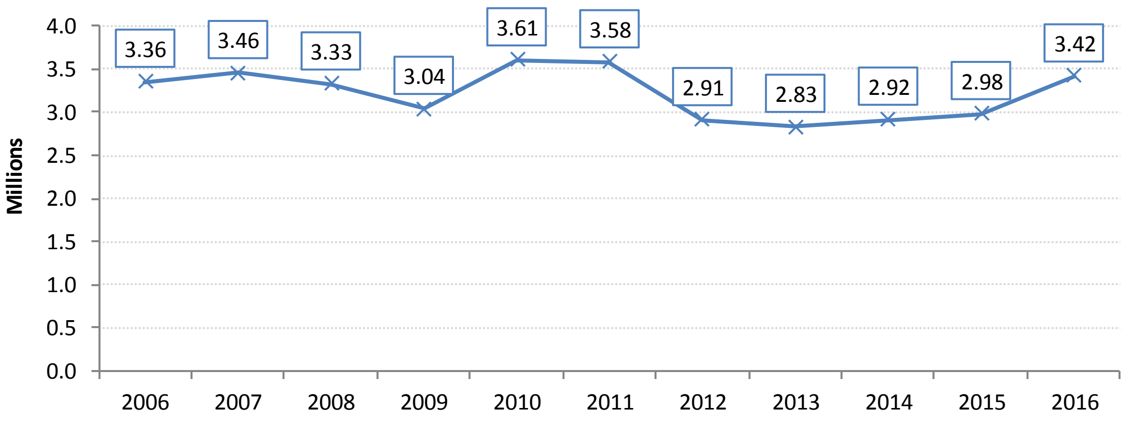
Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

1.1.3.1.7. PSA Group

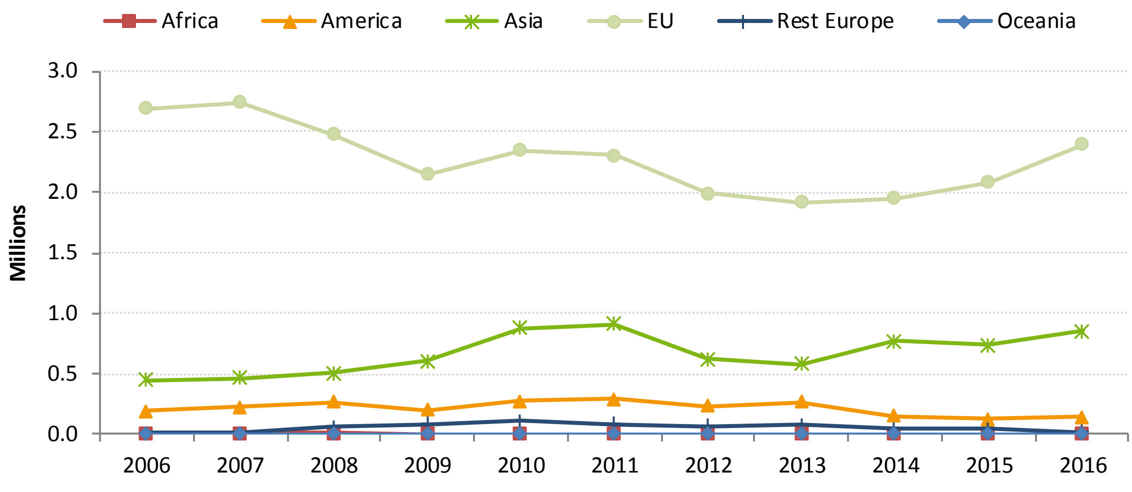
The data include the Peugeot, Citroën, and DS brands. In 2017, PSA acquired Germany's Opel and its UK sister brand Vauxhall for €2.2 billion from General Motors.

Figure 45
Total Units Produced: PSA



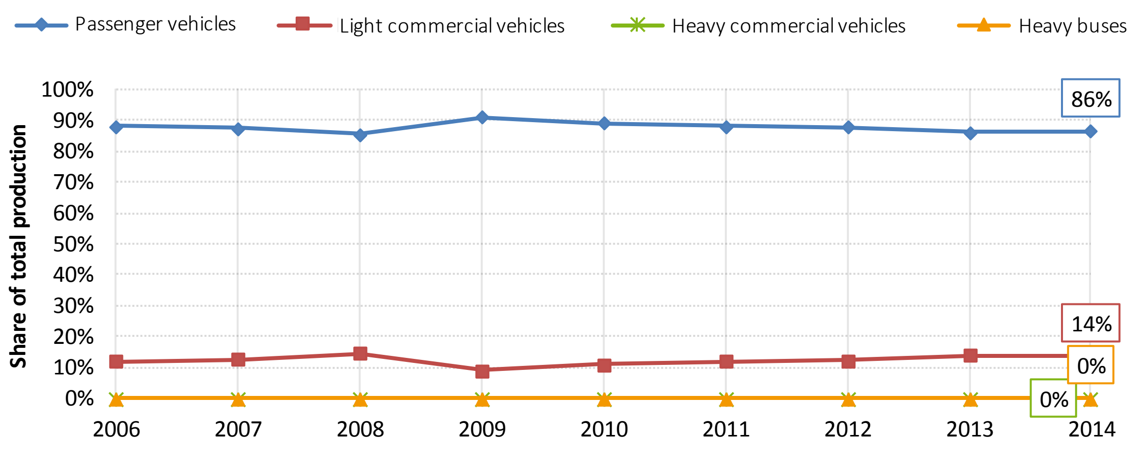
Source: OICA, production data.

Figure 46
Total Produced by Region: PSA



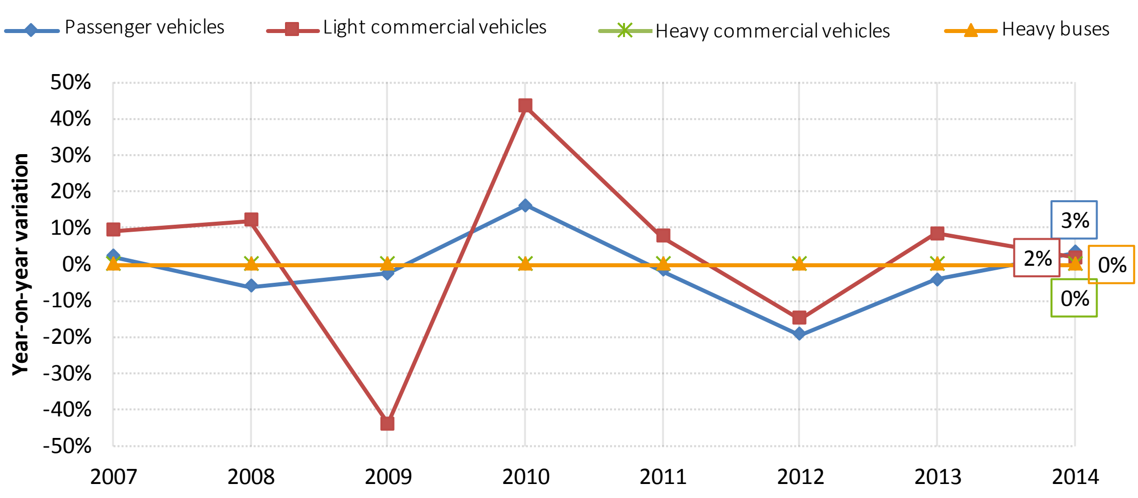
Rest Europe: Russia, Turkey
Africa: Morocco
Source: OICA, production data.

Figure 47
Production by Vehicle Type: PSA



Source: OICA, production data.
Note: Vehicle type was not specified in the 2015–16 data.

Figure 48
Production by Vehicle Type: PSA



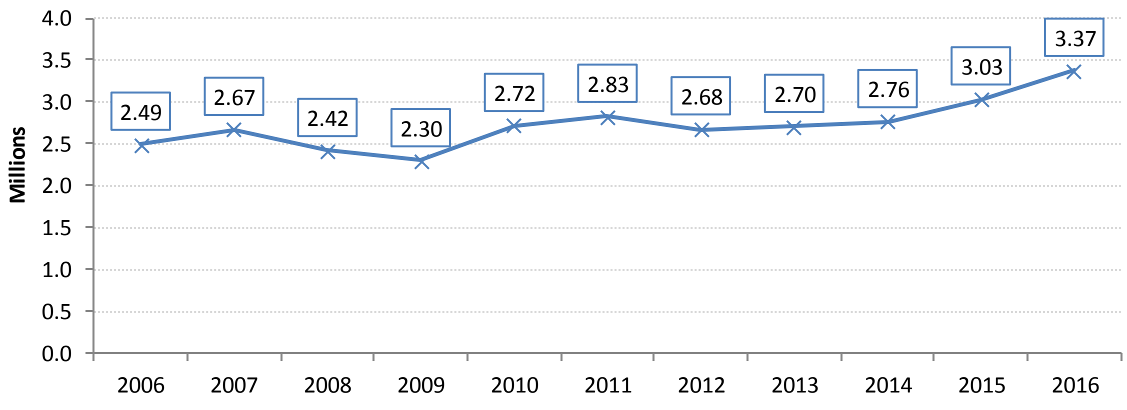
Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

1.1.3.1.8. Renault Group

The data include the Renault and Dacia brands.

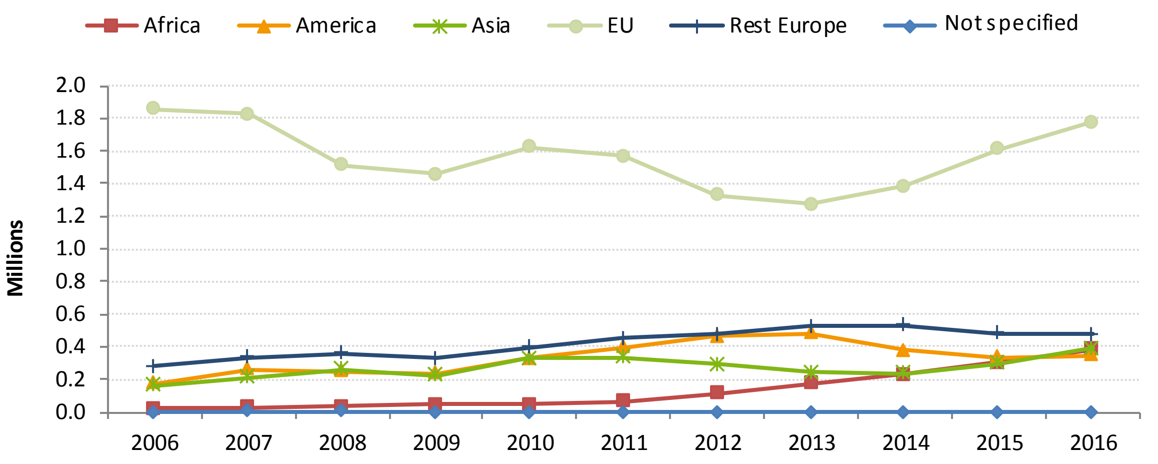
Figure 49
Total Units Produced: Renault



Source: OICA, production data. Dacia and Samsung included.

Figure 50

Total Produced by Region: Renault



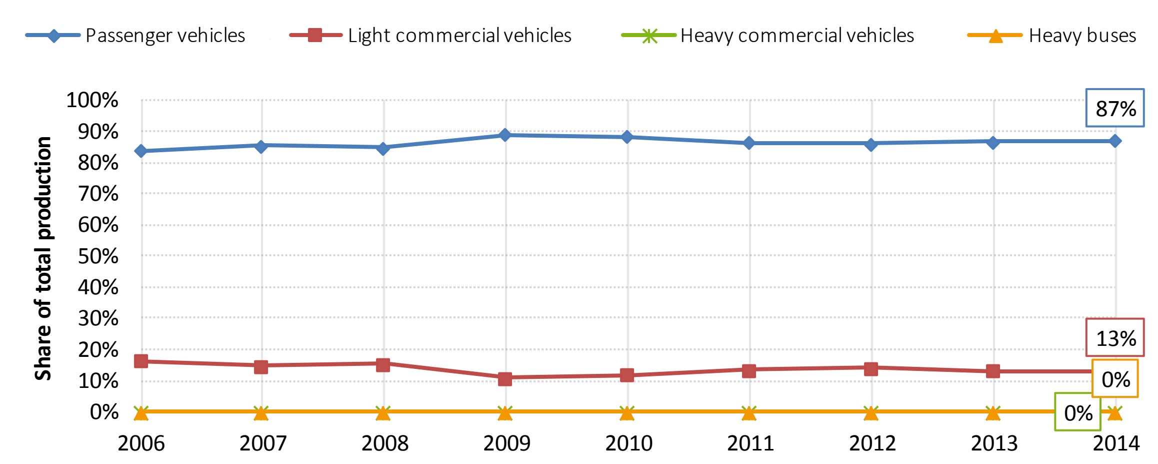
Source: OICA, production data.
Dacia and Samsung included.

Rest Europe: Russia, Turkey
Africa: Algeria, Morocco

Note: Vehicle type was not specified in the 2015–16 data.

Figure 51

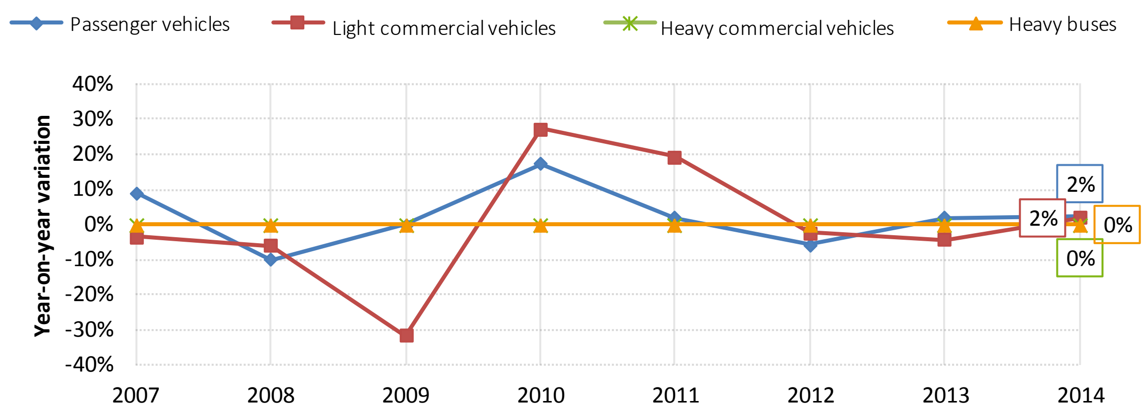
Production by Vehicle Type: Renault



Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

Figure 52
Production by Vehicle Type: Renault



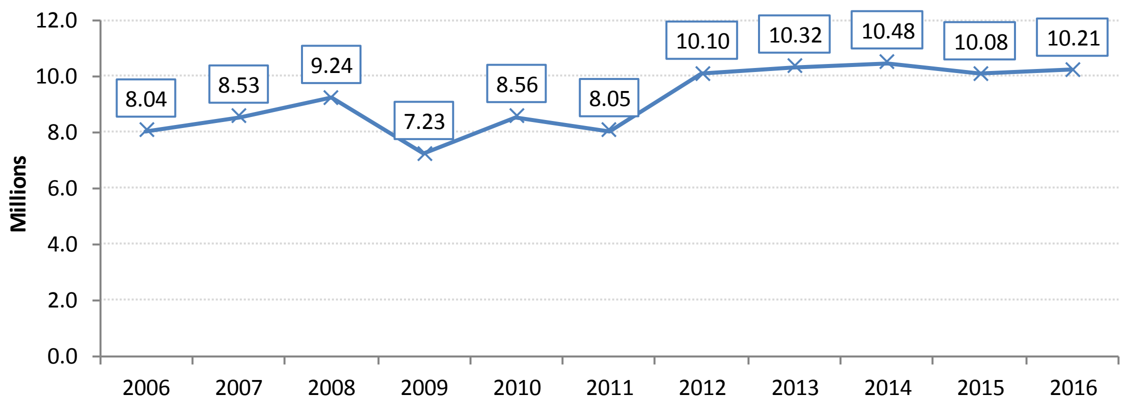
Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

1.1.3.1.9. Toyota Group

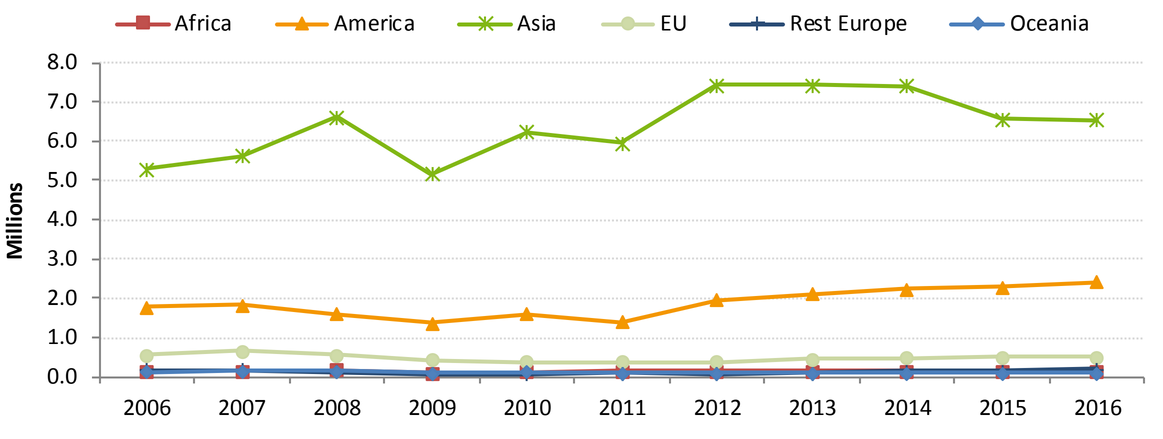
The data include the Toyota, Hino, and Daihatsu brands, as well as the premium brand Lexus.

Figure 53
Total Units Produced: Toyota Group



Source: OICA, production data.

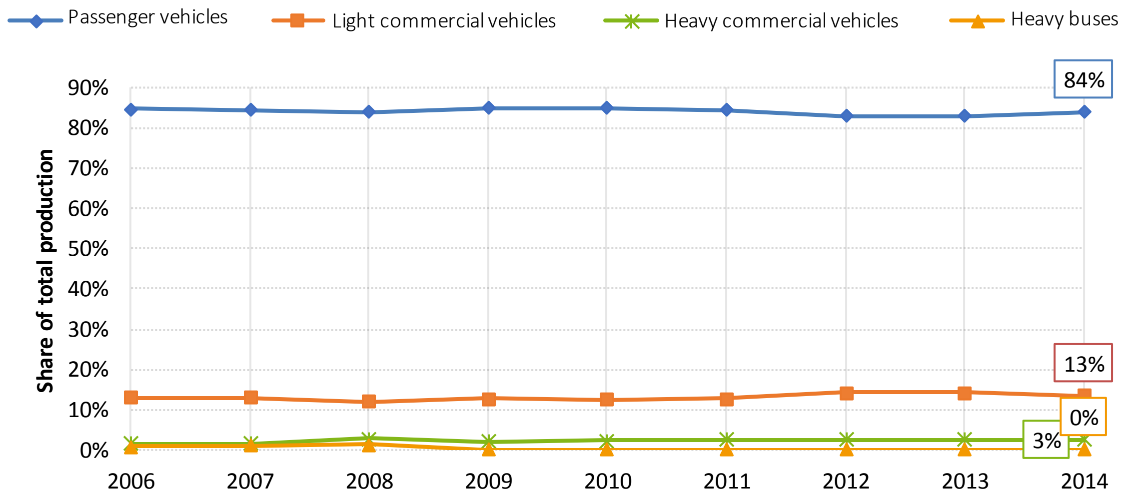
Figure 54
Total Produced by Region: Toyota Group



Rest Europe: Turkey, Russia. **Africa:** Egypt, South Africa, Kenya

Source: OICA, production data.

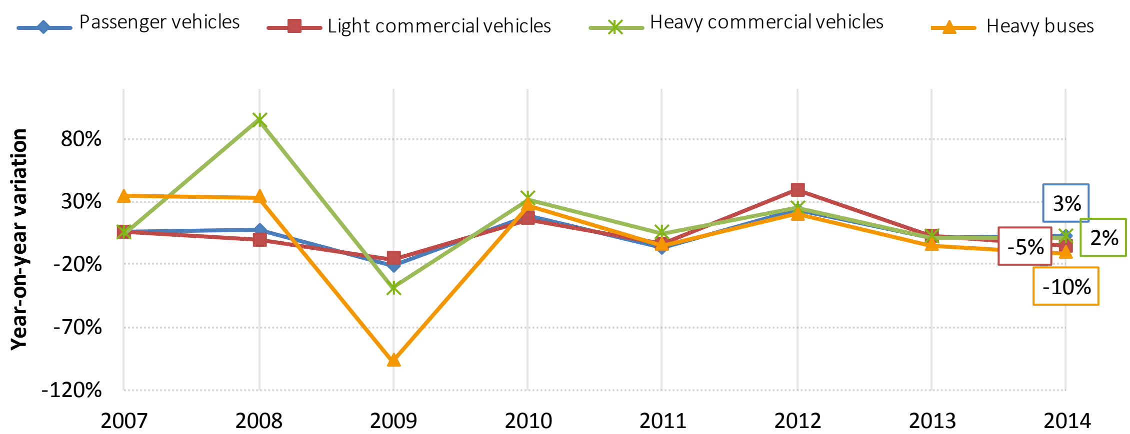
Figure 55
Production by Vehicle Type: Toyota Group



Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

Figure 56
Production by Vehicle Type: Toyota Group



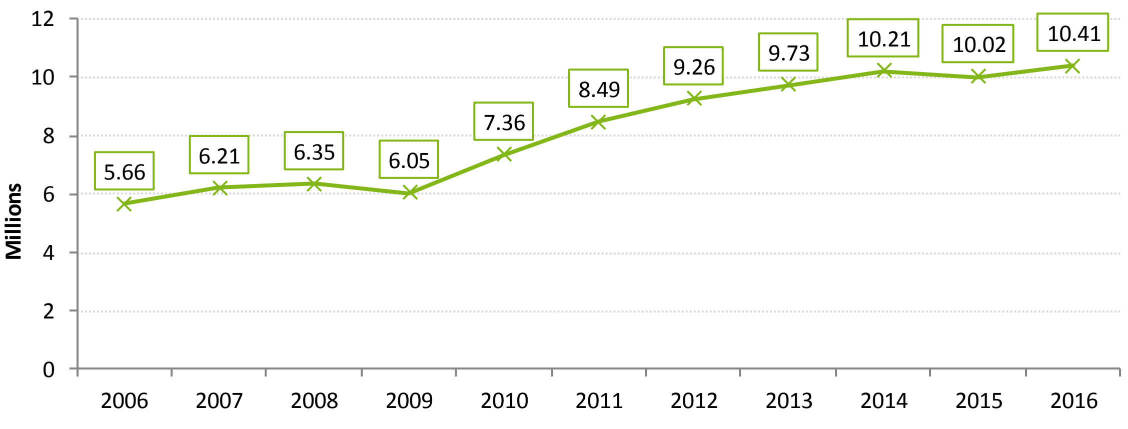
Source: OICA, production data.

Note: Vehicle type was not specified in the 2015–16 data.

1.1.3.1.10. Volkswagen Group

The data include the brands Volkswagen Passenger Cars, Audi, Škoda, Seat, Bentley, Porsche, Volkswagen Commercial Vehicles, Scania, and MAN, as well as the Chinese joint ventures Shanghai-Volkswagen and FAW-Volkswagen.

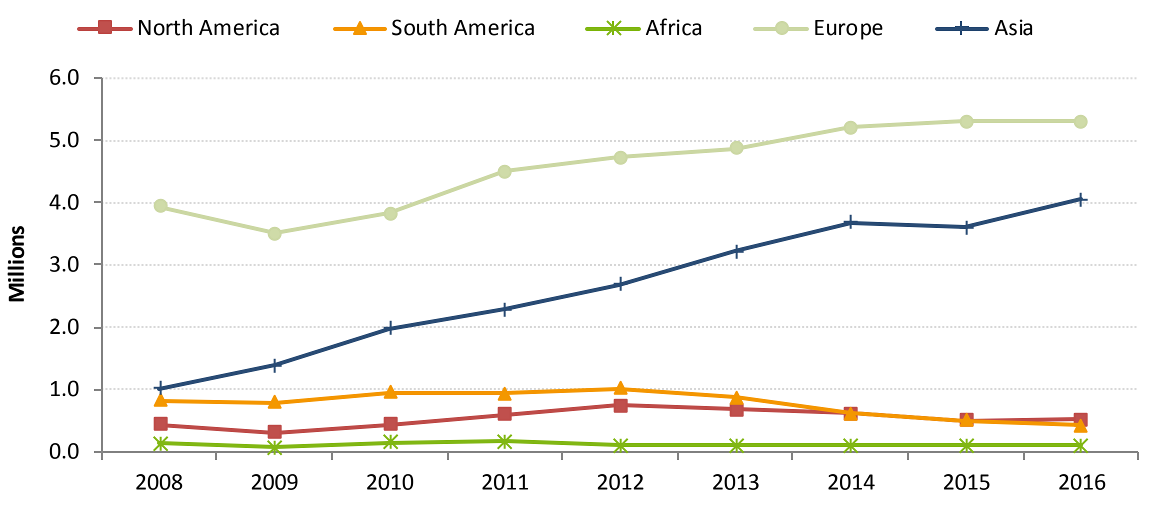
Figure 57
Total Units Produced: VW Group



Sources: VW Group annual reports, production data.
Note: All VW Group brands are included.

Figure 58

Total Produced by Region: VW Group

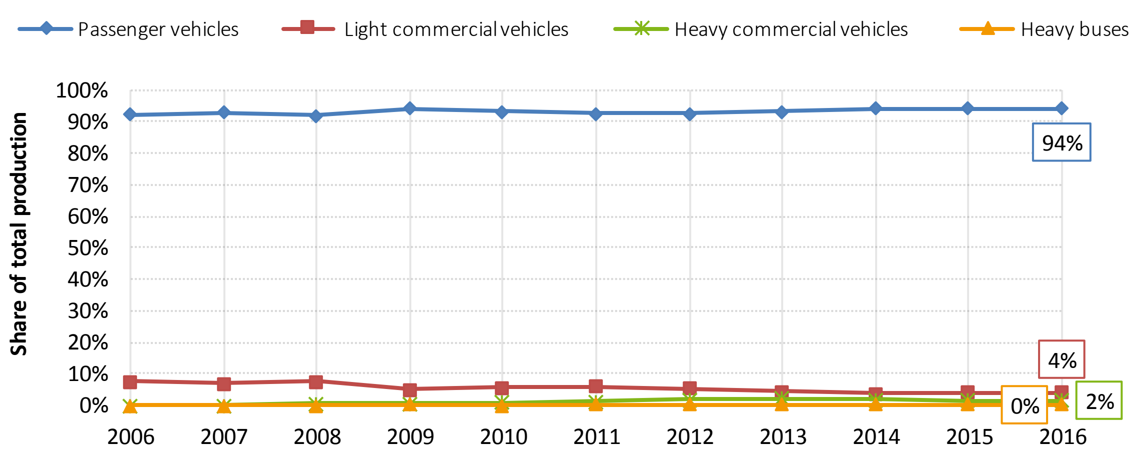


Sources: VW Group annual reports, production data.

Note: All VW Group brands are included.

Figure 59

Production by Vehicle Type: VW Group



Sources: VW Group annual reports, production data.

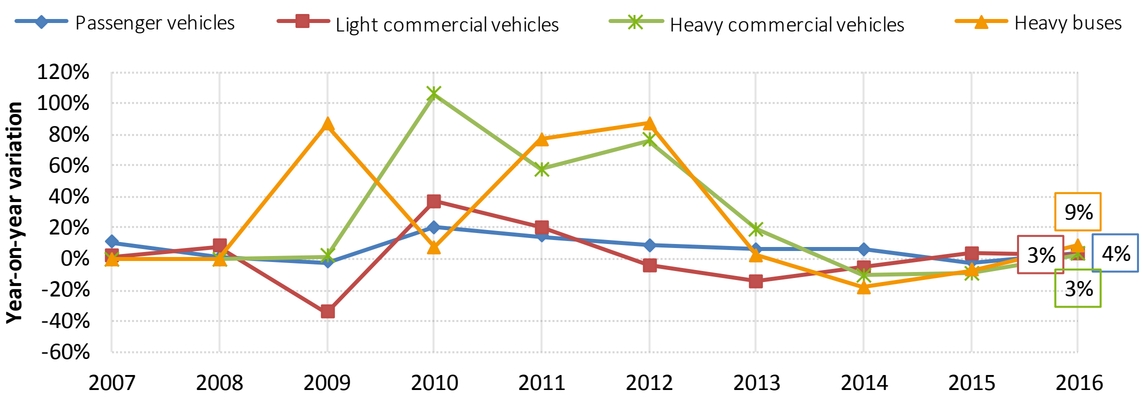
Passenger vehicles include Volkswagen, Audi, Škoda, Seat, Bentley and Porsche.

Light commercial vehicles include Volkswagen vans and trucks.

Heavy commercial vehicles includes Scania and MAN trucks.

Heavy buses includes Scania and MAN buses.

Figure 60
Production by Vehicle Type: VW Group



Sources: VW Group annual reports, production data.

Passenger vehicles include Volkswagen, Audi, Škoda, Seat, Bentley and Porsche.

Light commercial vehicles include Volkswagen vans and trucks.

Heavy commercial vehicles includes Scania and MAN trucks.

Heavy buses includes Scania and MAN buses.

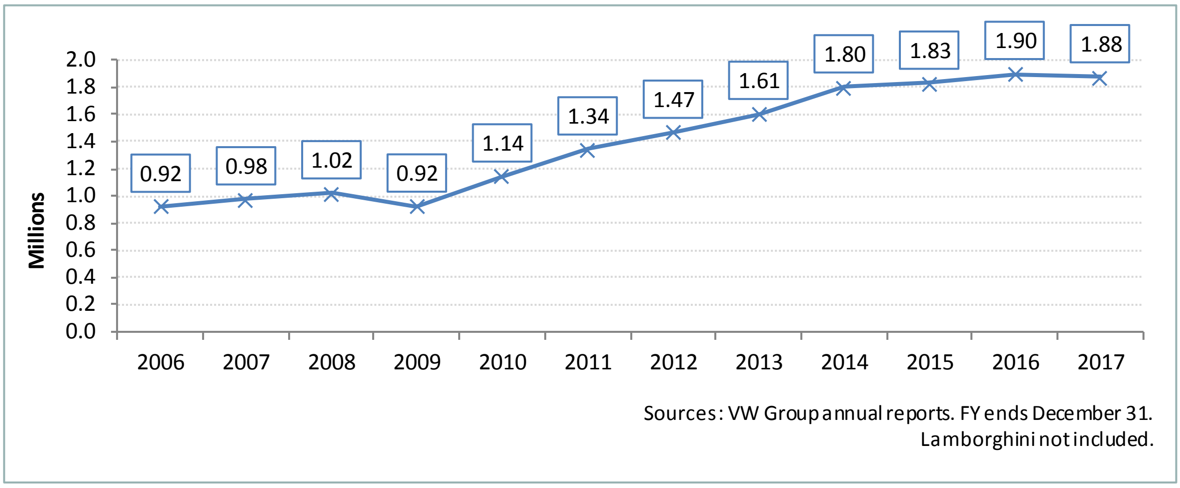
1.1.3.2. Premium Segment

> "A premium brand is defined through innovation and innovative capabilities, which are clearly communicated by means of marketing and corporate appearance. Premium brands are global and strong in their home market and offer high residual values. Contrary to the purely arbitrary and discriminatory price-setting strategy of luxury brands, the price position of a premium product is explicable by means of enhanced classic free-market pricing mechanisms."[32]

[32] Philipp G. Rosengarten and Christoph B. Stuermer, *Premium Power* (Basingstoke, England: Palgrave Macmillan, 2006).

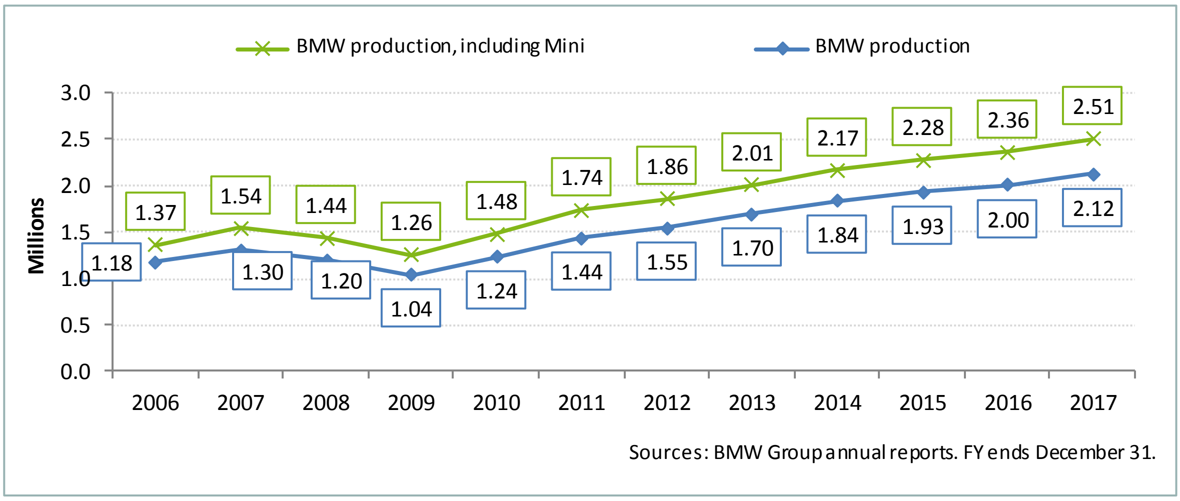
1.1.3.2.1. Audi (Volkswagen Group)

Figure 61
Total Units Produced: Audi



1.1.3.2.2. BMW Group

Figure 62
Total Units Produced: BMW



1.1.3.2.3. Infiniti (Nissan Motor Company)

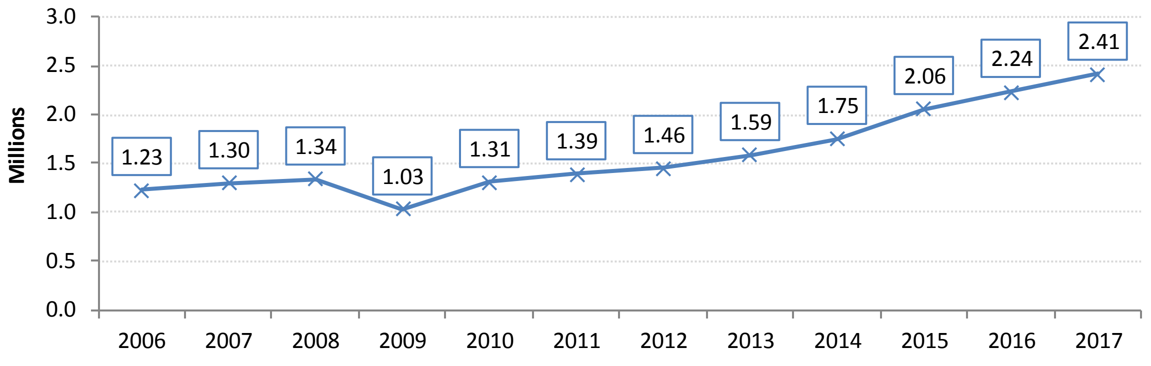
No data available.

1.1.3.2.4. Lexus

No data available.

1.1.3.2.5. Mercedes (Daimler Group)

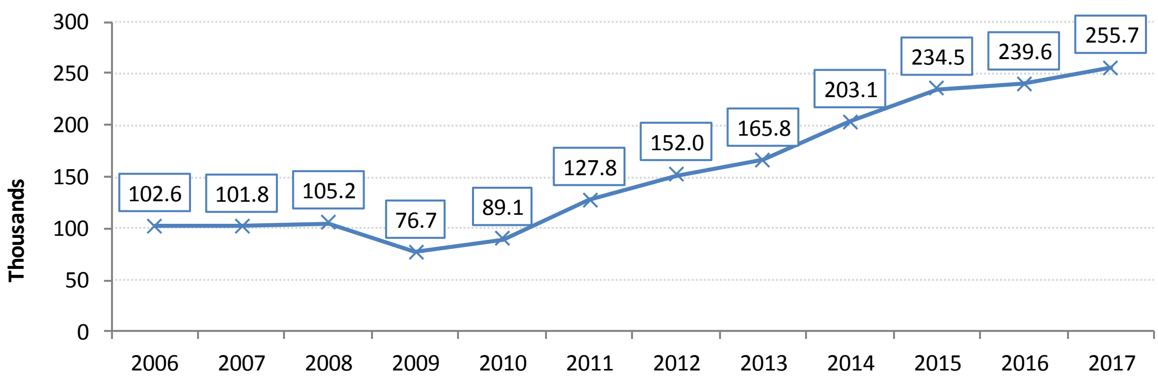
Figure 63
Total Units Produced: Mercedes



Sources: Daimler annual reports. FY ends December 31.
Smart included. Commercial vehicles not included.

1.1.3.2.6. Porsche

Figure 64
Total Units Produced: Porsche



Sources: Porsche annual reports. Fiscal year ends December 31.

1.1.3.2.7. Volvo

No data available.

1.2. Sales

Sales of motor vehicles continued to rise in 2017. New registrations of motor vehicles reached 96.8 million units worldwide in 2017, an increase of 3.1% compared to 2016. Cars accounted for 73% of total sales. The remainder were commercial vehicles, a category that saw an annual increase of 6.4%.

Global sales for new passenger cars reached 70.8 million units in 2017, an increase of 1.9% compared to 2016 and exceeding precrisis levels by 39% (2007: 50.6 million units sold) (OICA, sales data). However, not all of the top markets had increases in car registrations in 2017. While Chinese demand increased by 2.4%, sales of passenger car decreased by 11.3% in the United States, 5.7% in the United Kingdom, and 4.6% in Mexico (OICA, sales data).

Passenger car sales in the European Union reached 15.7 million units in 2017, up 3.3% on the previous year and accounting for 22% of the global passenger car market.

Sales of light vehicles (including pickups and vans) reached 17.14 million in the United States in 2017. Passenger car sales in the United States totaled 6.1 million in 2017, declining 11.3% in annual terms. Light truck sales (which include pickups and vans) totaled 11 million units in 201effectively turning the United States into a market of pickups and SUVs. (Bureau of Economic Analysis, BEA, 2018).[33]

Passenger car sales in China totaled almost 30 million units in 2017, putting the country at the top of the sales ranking for the ninth consecutive year. As a result, China's market share of global passenger car sales rose to 35% (OICA, sales data).

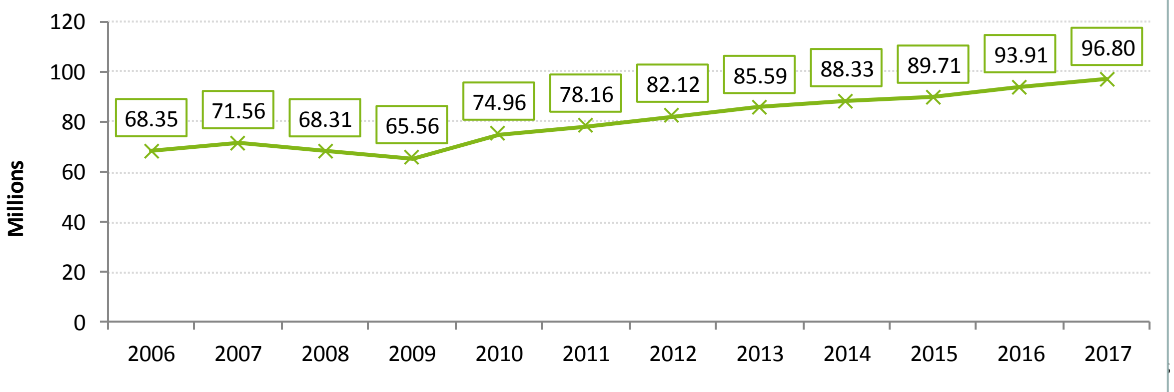
Passenger car sales in Japan increased by 5.9% in 2017, recovering from a contraction in 2015. Car sales were still 6.6% below the 2014 level.

Asia (excluding China and Japan), Oceania and the Middle East experienced 3.9% year-on-year growth of passenger car sales in 2017, mainly on the back of a strong growth rate of 8.8% in India (OICA, sales data).

In terms of sales ranking (total vehicle sales, including passenger and commercial vehicles), China continued to lead in 2017, followed by the United States. Japan was third and India was fourth. Fifth place was taken by Germany, which was overtaken by India in that year (OICA, sales data).

1.2.1. Worldwide Sales by Segment

Figure 65
Total Motor Vehicles Sold Worldwide



Source: OICA, sales data.

Figure 66
Total Cars Sold Worldwide

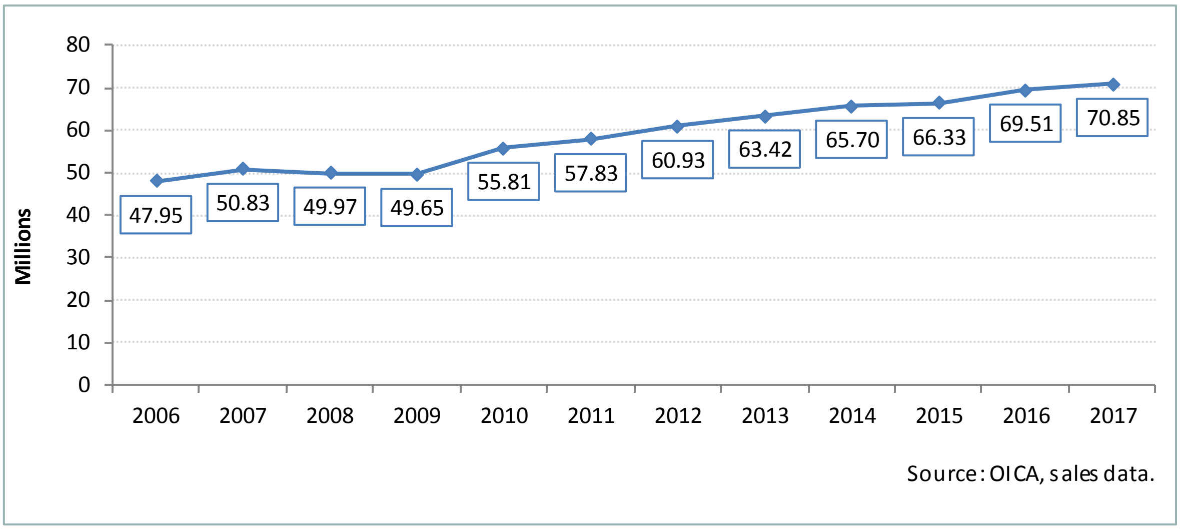
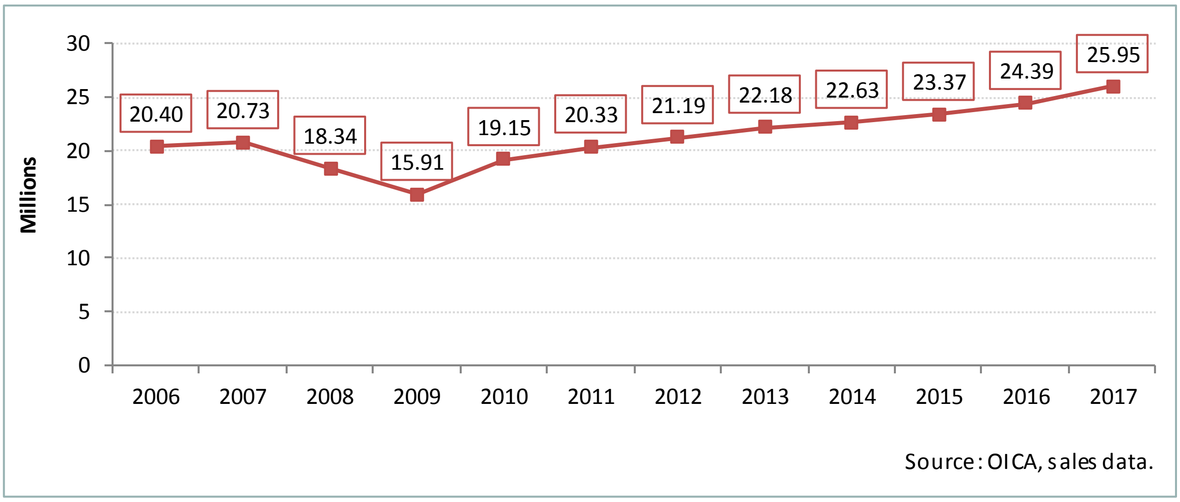
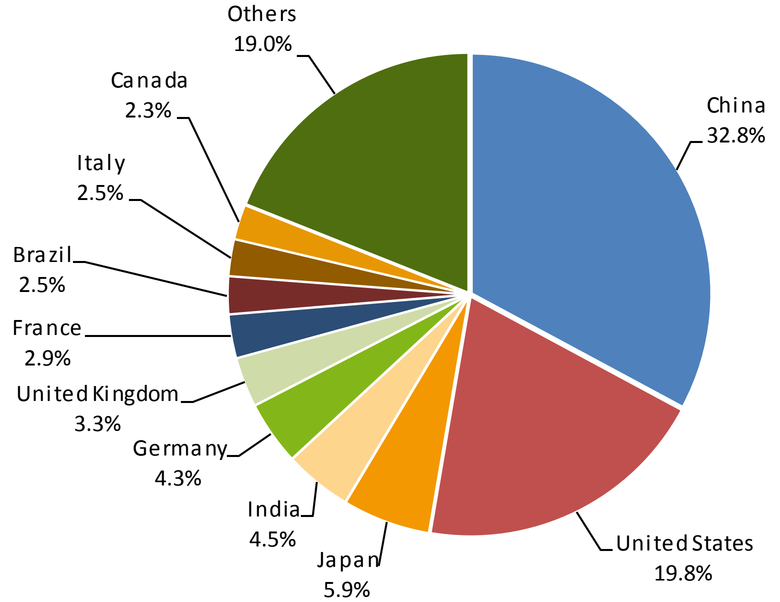


Figure 67
Total Commercial Vehicles Sold Worldwide



1.2.2. Top Countries

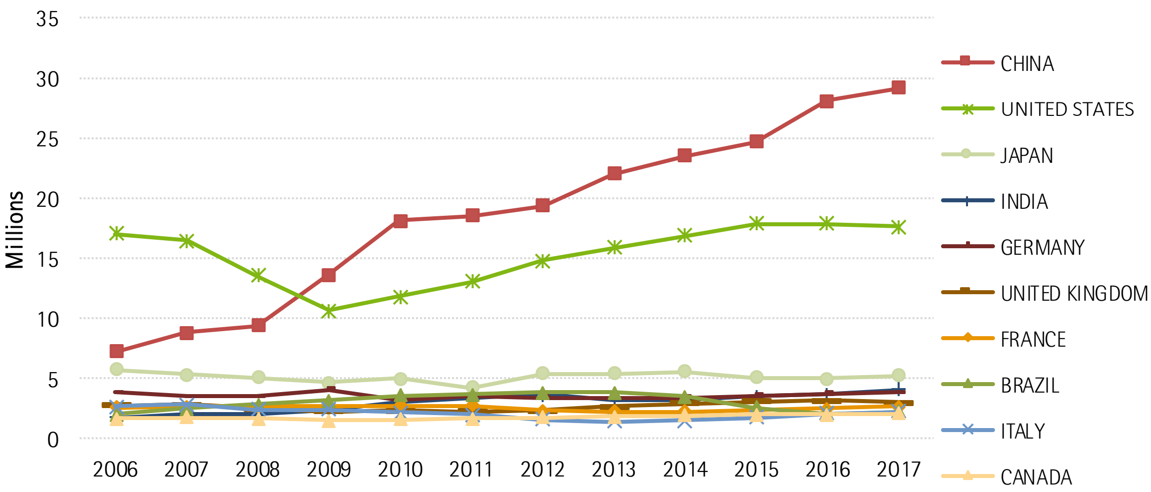
Figure 68
Top 10 Markets in the Automotive Industry in 2017



Total motor vehicles sold worldwide in 2017: 96,804,390

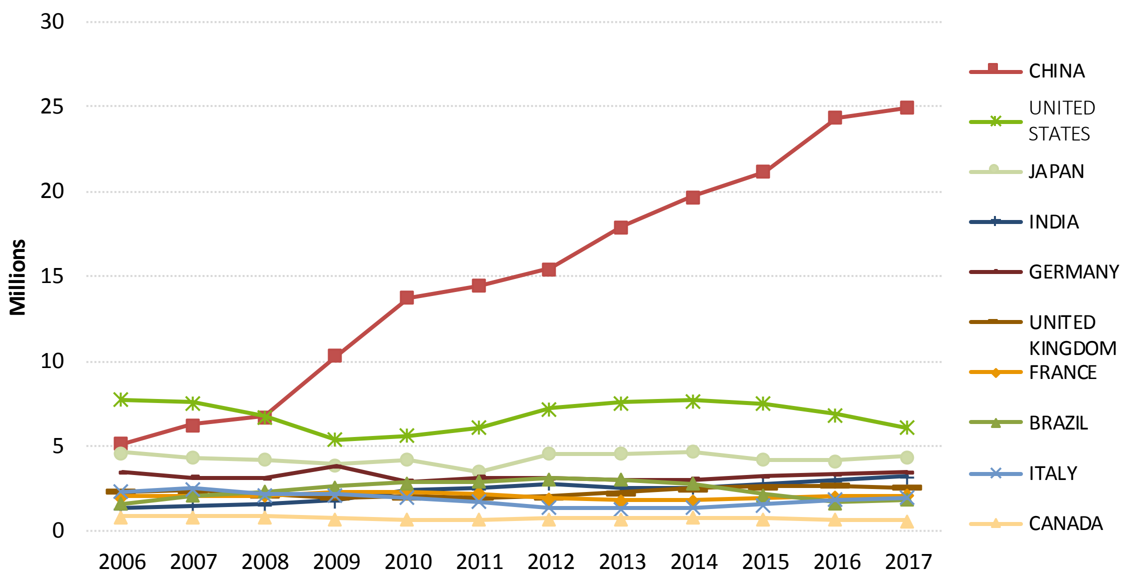
Source: OICA, sales data.

Figure 69
Top OICA Markets in 2017: Total Motor Vehicles Sold



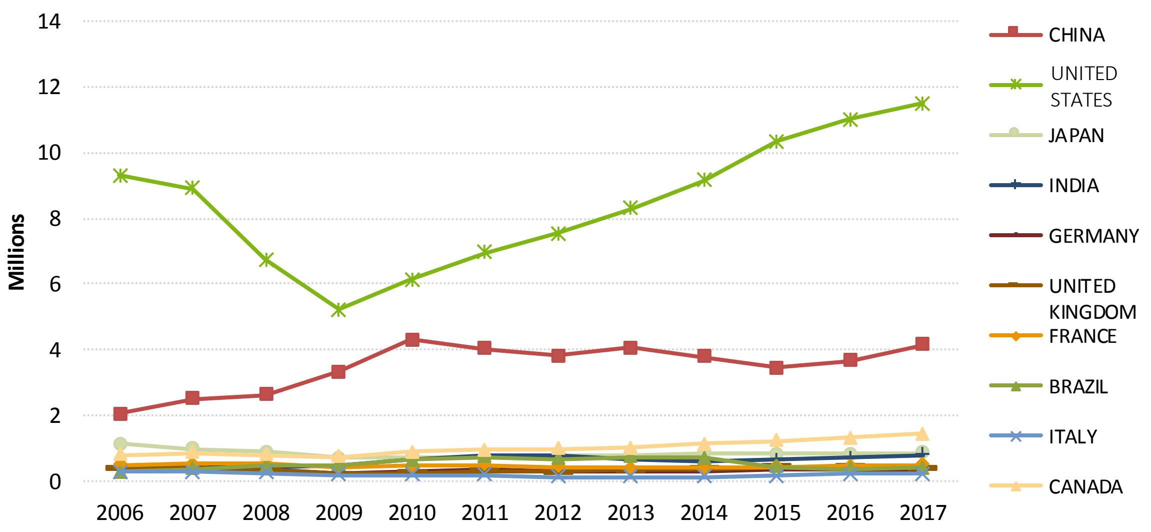
Source: OICA, sales data.

Figure 70
Top OICA Markets in 2017: Total Passenger Cars Sold



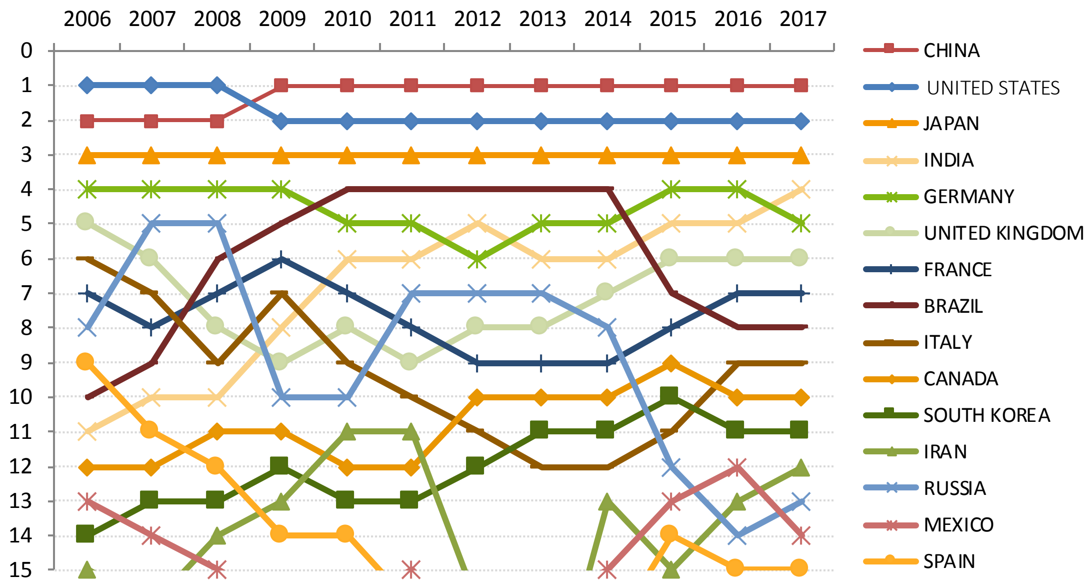
Source: OICA, sales data.

Figure 71
Top OICA Markets in 2017: Total Commercial Vehicles Sold



Source: OICA, sales data.

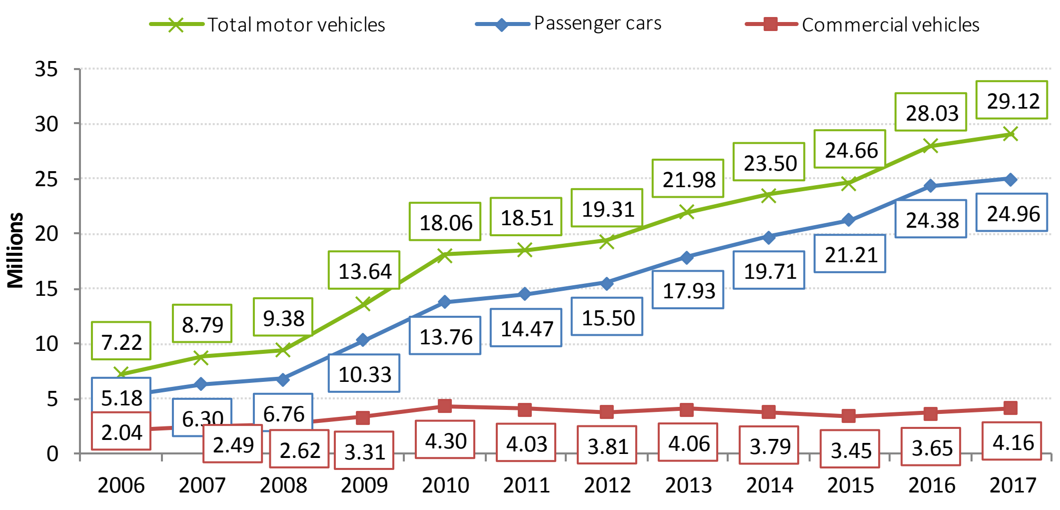
Figure 72
OICA Countries' Sales Ranking (Total Motor Vehicles)



Source: OICA, sales data.

1.2.2.1. Annual Sales by Segment (Units): China

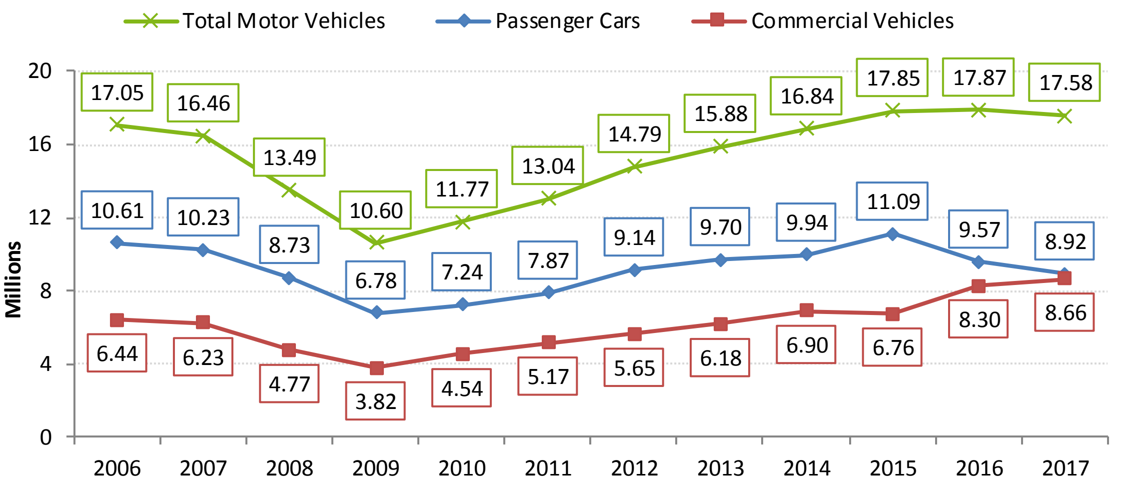
Figure 73
China: Vehicle Sales



Source: OICA, sales data.

1.2.2.2. Annual Sales by Segment (Units): United States

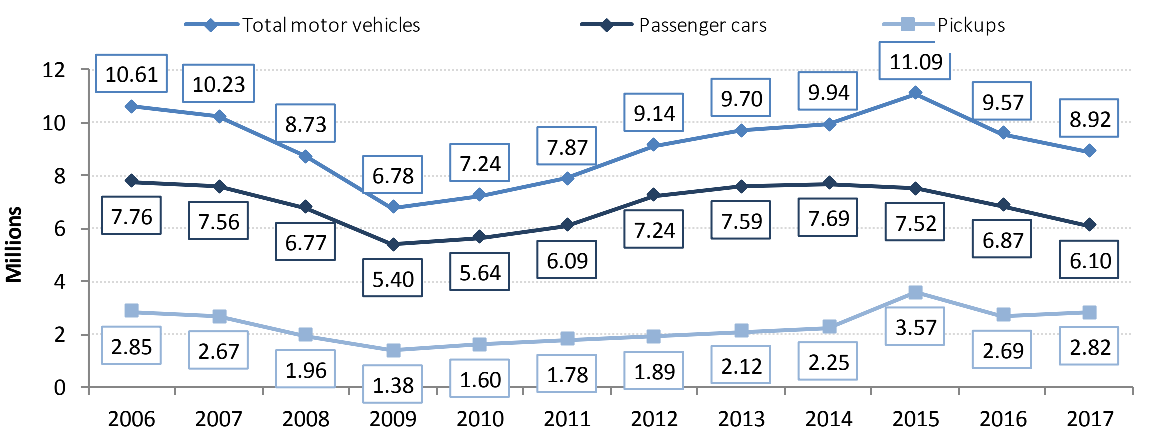
Figure 74
United States: Vehicle Sales



Sources: OICA sales data, for passenger cars and commercial vehicles; WardsAuto sales data and Center for Automotive Research (CAR) sales data, for pickups.

Note: Passenger vehicles include passenger cars and pickups.
Commercial vehicles include light trucks (excluding pickups), heavy trucks, buses and coaches.

Figure 75
United States: Passenger Vehicle Sales

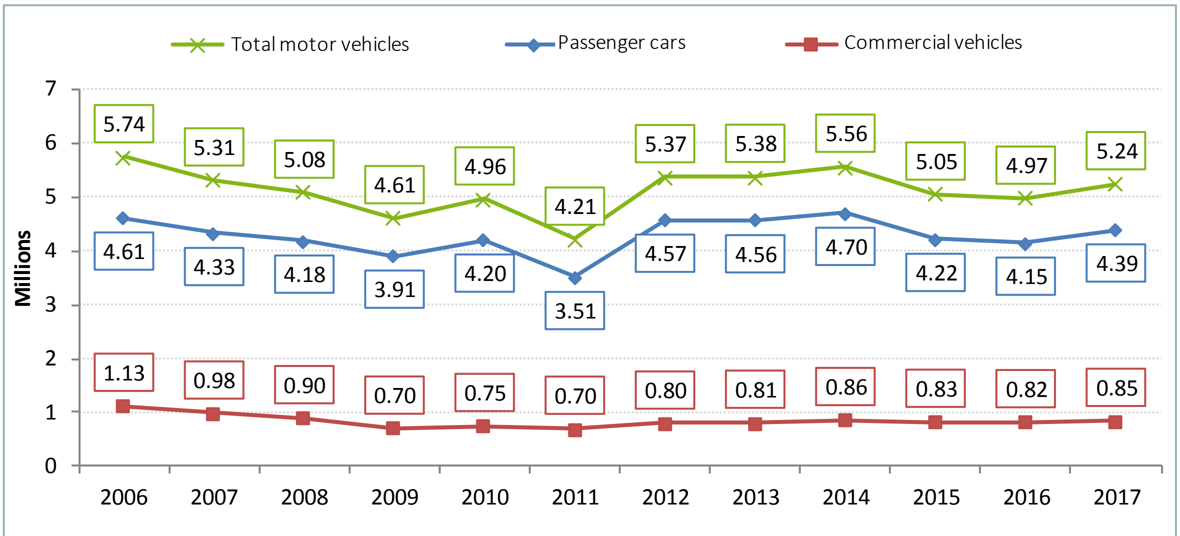


Sources: OICA sales data, for passenger cars; WardsAuto sales data and CAR sales data, for pickups.

Note: Total passenger vehicles include passenger cars and pickups.

1.2.2.3. Annual Sales by Segment (Units): Japan

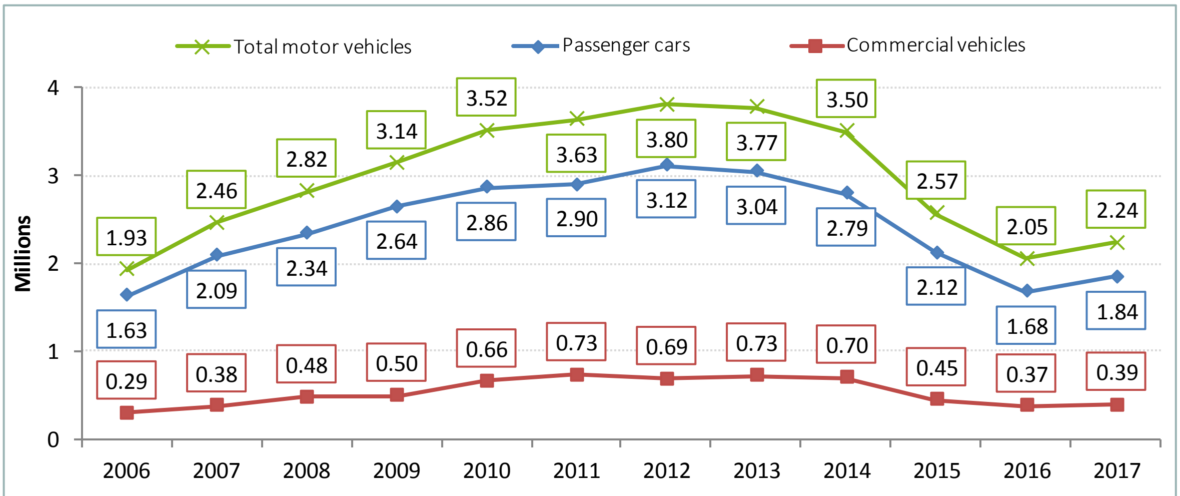
Figure 76
Japan: Vehicle Sales



Source: OICA, sales data.

1.2.2.4. Annual Sales by Segment (Units): Brazil

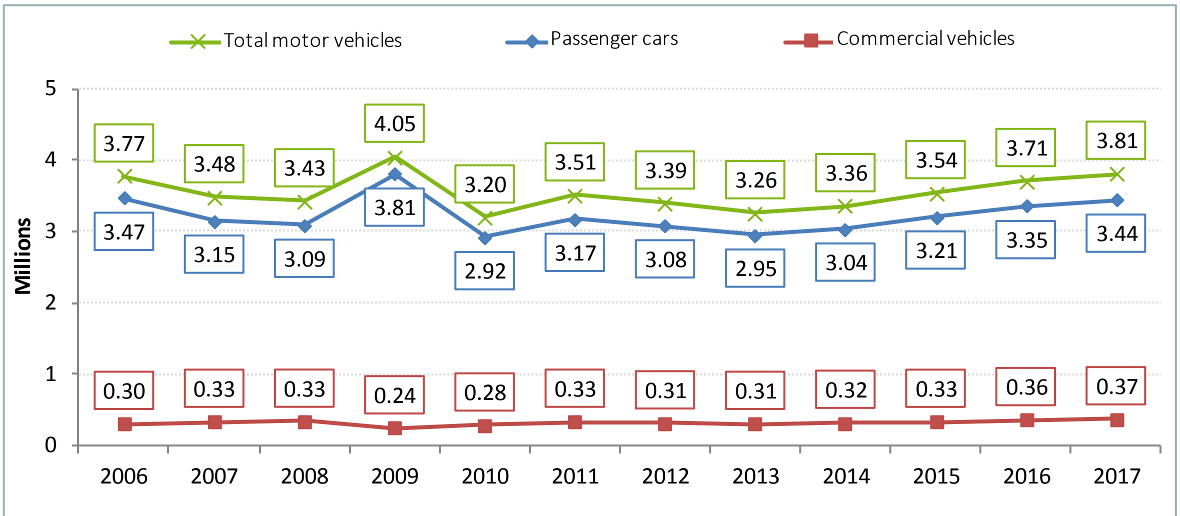
Figure 77
Brazil: Vehicle Sales



Source: OICA, sales data.

1.2.2.5. Annual Sales by Segment (Units): Germany

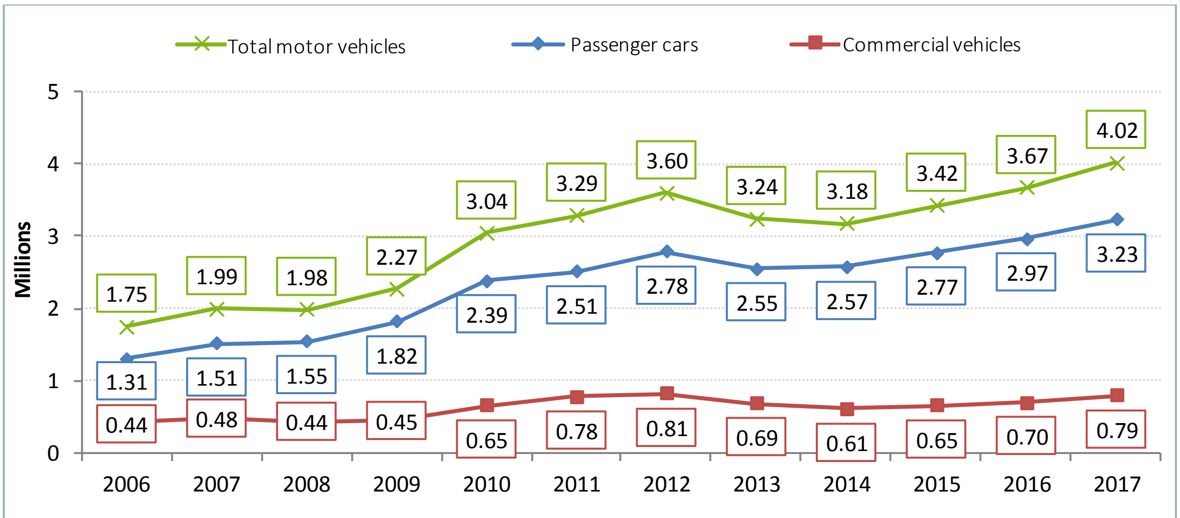
Figure 78
Germany: Vehicle Sales



Source: OICA, sales data.

1.2.2.6. Annual Sales by Segment (Units): India

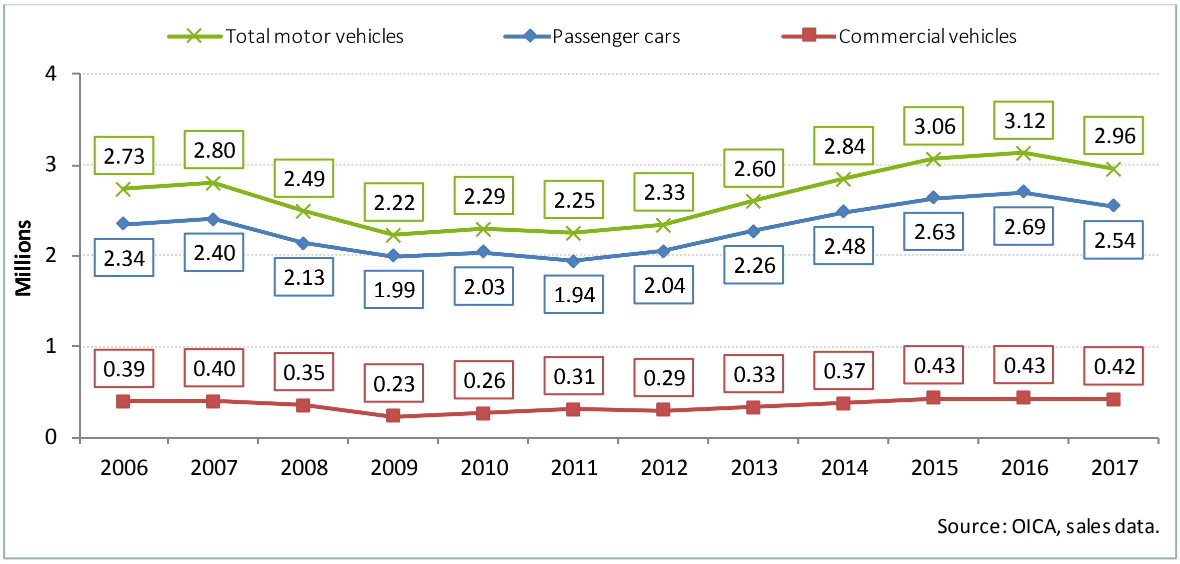
Figure 79
India: Vehicle Sales



Source: OICA, sales data.

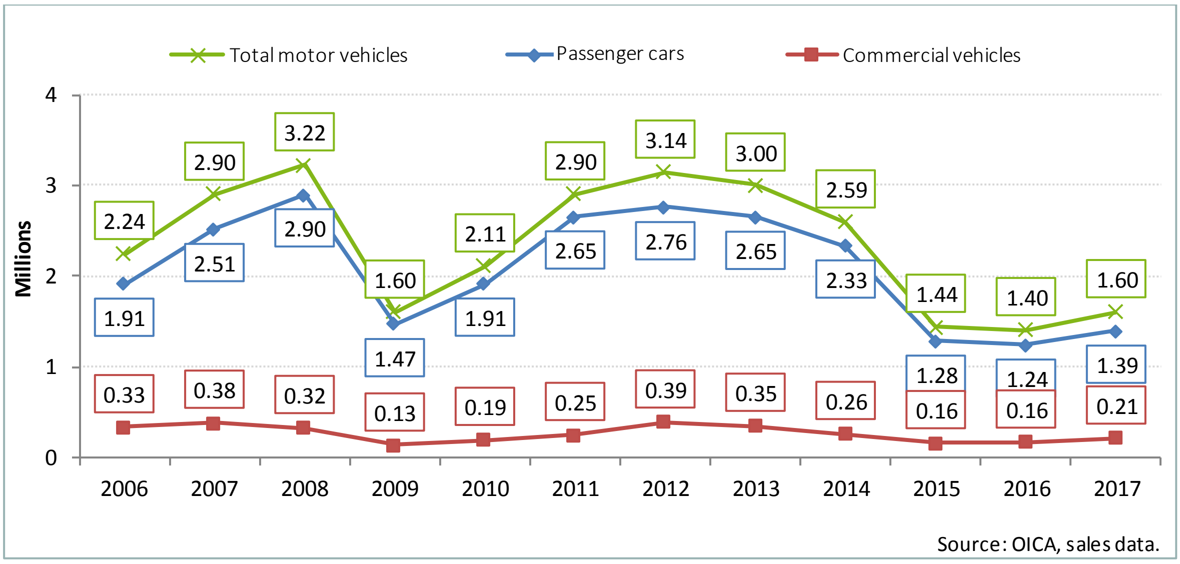
1.2.2.7. Annual Sales by Segment (Units): United Kingdom

Figure 80
United Kingdom: Vehicle Sales



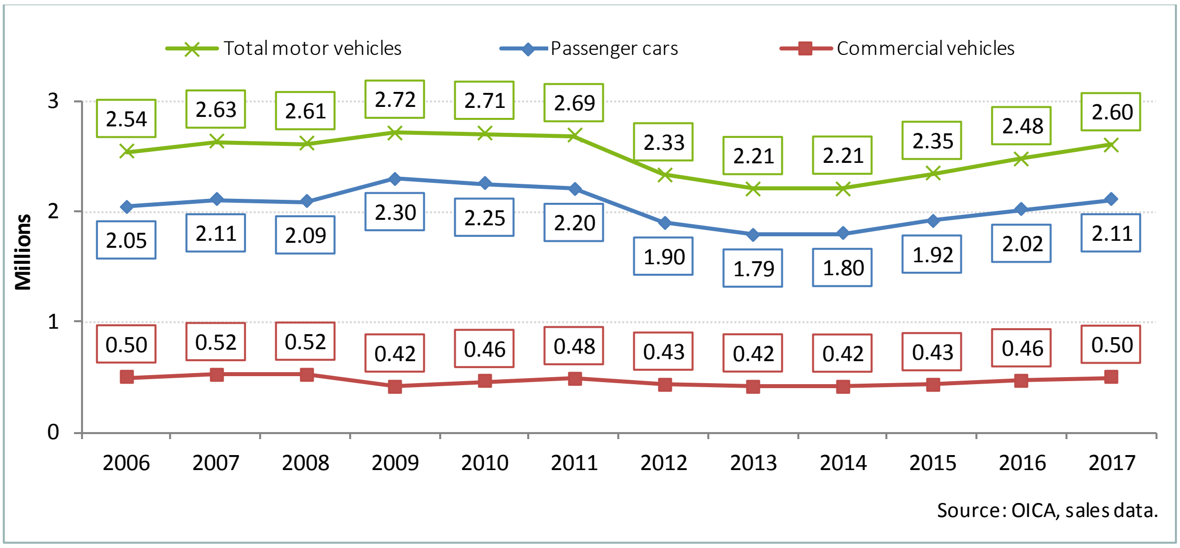
1.2.2.8. Annual Sales by Segment (Units): Russia

Figure 81
Russia: Vehicle Sales



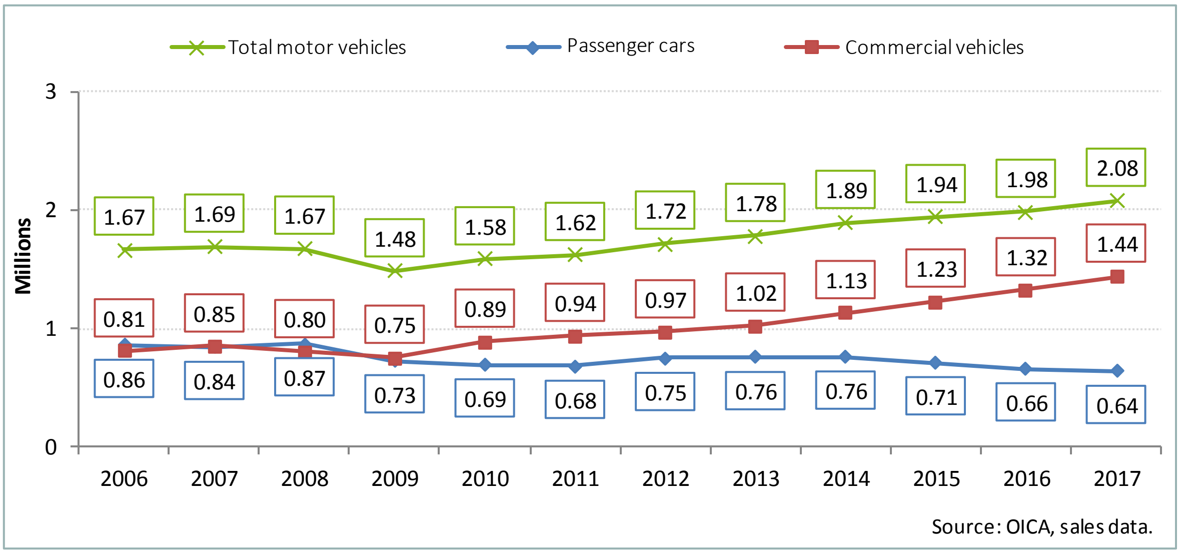
1.2.2.9. Annual Sales by Segment (Units): France

Figure 82
France: Vehicle Sales



1.2.2.10. Annual Sales by Segment (Units): Canada

Figure 83
Canada: Vehicle Sales



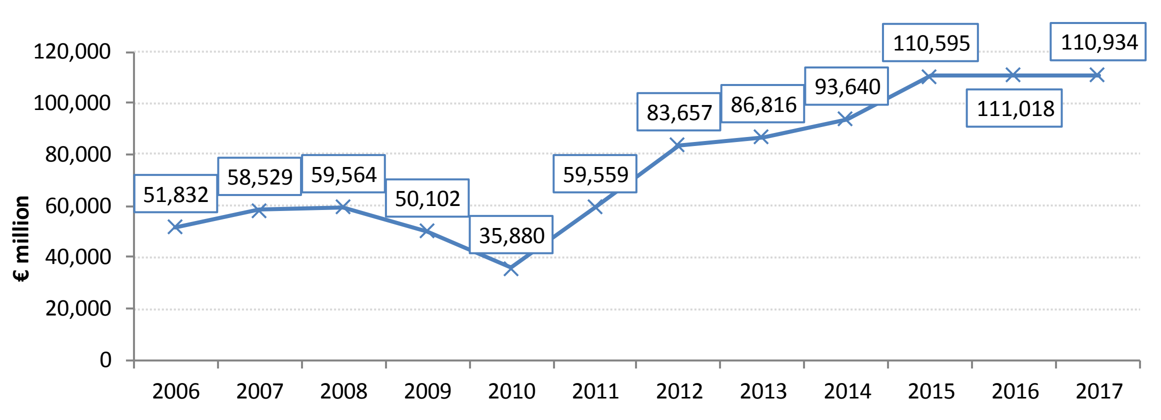
1.2.3. Top Manufacturers

While production data for the top manufacturers were taken from the OICA website (except for Volkswagen Group production), all sales data was based on the manufacturers' publications. OICA does not publish sales data by manufacturer.

1.2.3.1 Volume Segment

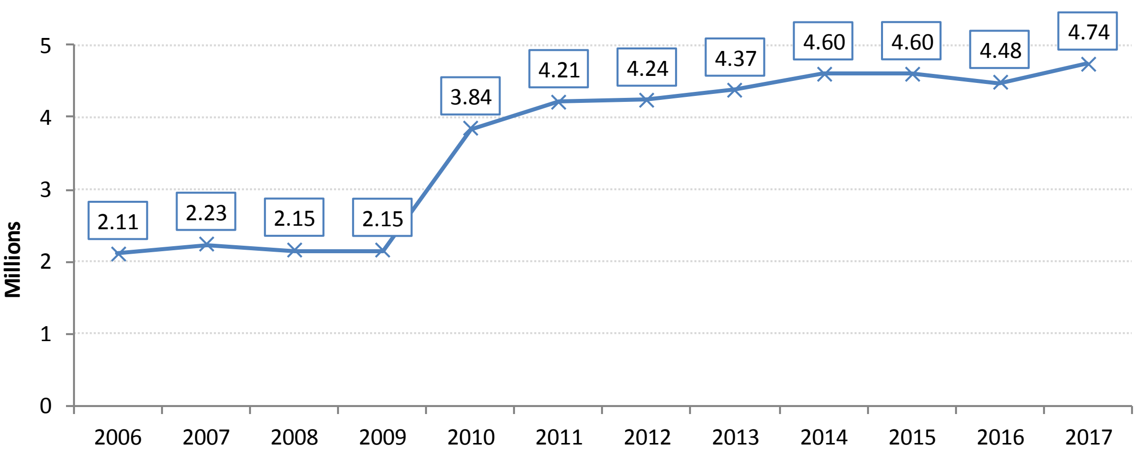
1.2.3.1.1. Fiat Chrysler Automobiles

Figure 84
Total Revenue: FCA



Sources: FCA annual reports. Components and other segments are included.
Fiscal year ends on December 31.

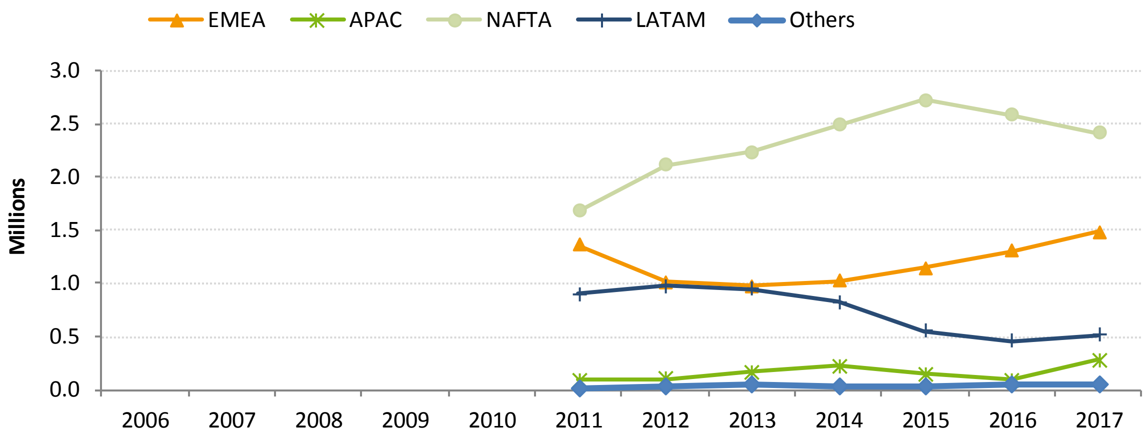
Figure 85
Total Unit Sales: FCA



Sources: FCA annual reports.
Fiscal year ends on December 31.

Note: In 2013, Chrysler became a subsidiary of Fiat Chrysler Automobiles.

Figure 86
Unit Sales by Region: FCA



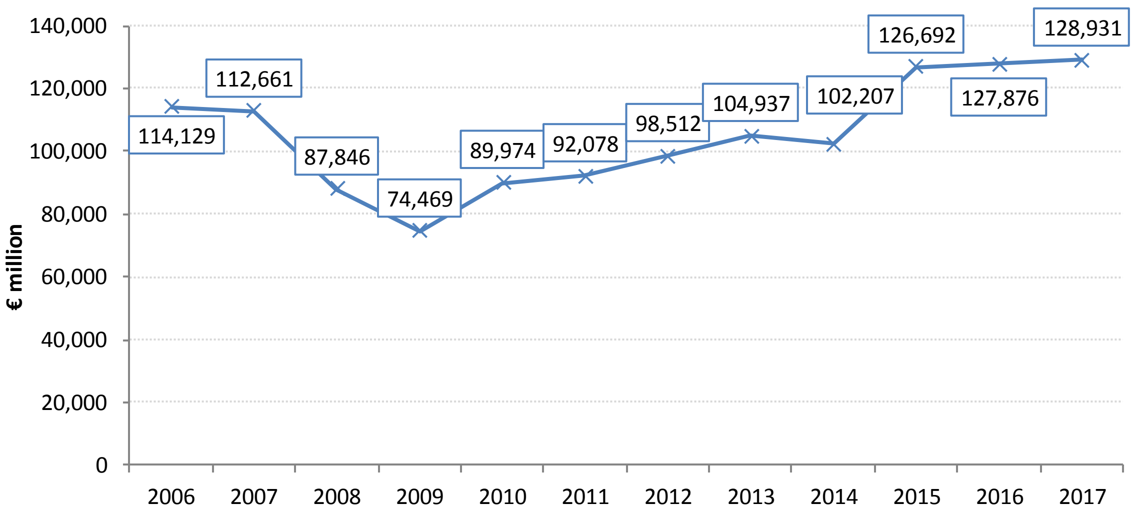
* **Others**: Maserati, Ferrari.

Sources: FCA annual reports.
Fiscal year ends on December 31.

Note: The region is not specified in the 2006–10 sales data.

1.2.3.1.2. Ford Motors

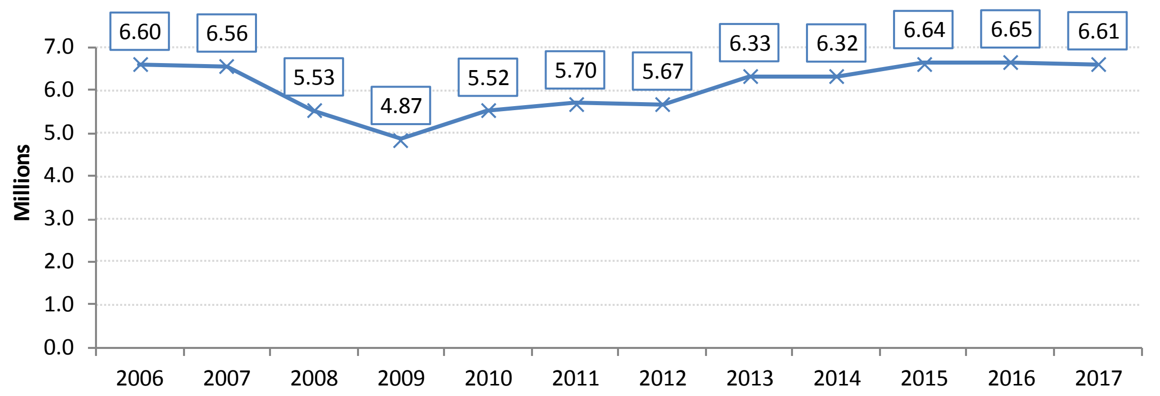
Figure 87
Total Revenue: Ford



Sources: Ford annual reports and ECB exchange rate data.
Fiscal year ends on December 31.

Note: The revenue data do not include sales from Ford-badged vehicles produced and distributed by unconsolidated affiliates, nor do the data include vehicles with the brand of the Chinese joint venture Jiangling Motors Corporation Ltd (JMC).

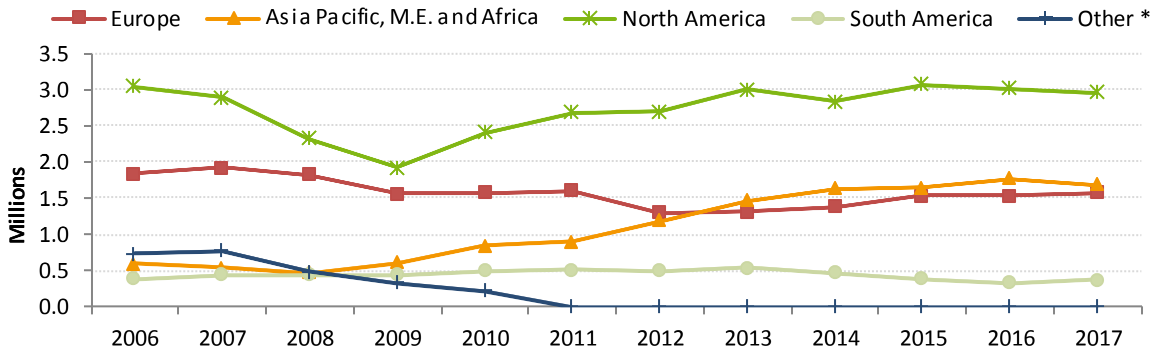
Figure 88
Total Unit Sales: Ford



Sources: Ford annual reports.
Fiscal year ends on December 31.

Note: The wholesale data include sales of passenger cars, light vehicles, and medium and heavy trucks.
The wholesale data include all Ford- and Lincoln-badged units (whether produced by Ford or by an unconsolidated affiliate) that are sold to dealerships, units manufactured by Ford that are sold to other manufacturers, units distributed for other manufacturers, and local brand units produced by the unconsolidated Chinese joint venture Jiangling Motors Corporation Ltd (JMC) that are sold to dealerships. Vehicles sold to daily rental car companies that are subject to a guaranteed repurchase option (rental repurchase), as well as other sales of finished vehicles for which the recognition of revenue is deferred (such as consignments), are also included in wholesale unit volumes.

Figure 89
Unit Sales by Region: Ford



*** Other**: Volvo, Jaguar Land Rover, Aston Martin.
Premier Automotive Group

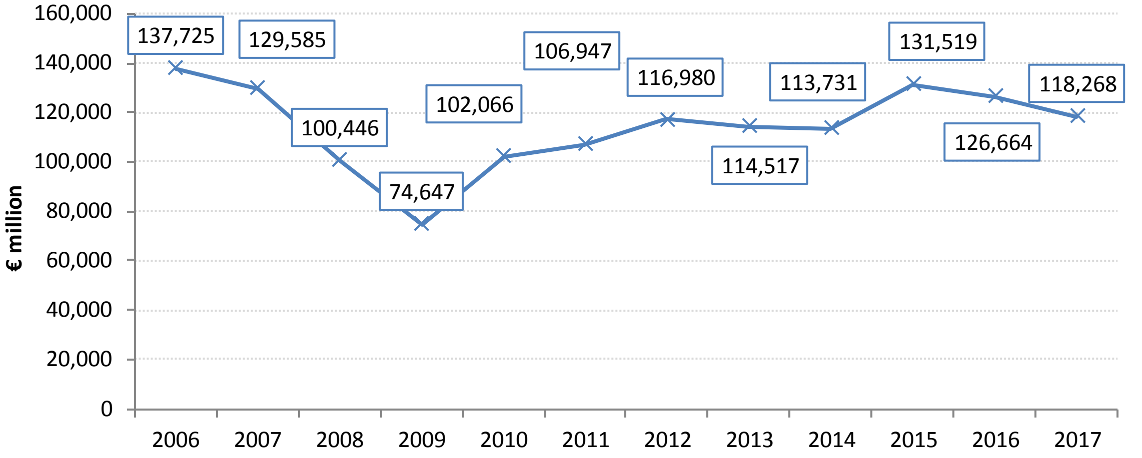
Sources: Ford Annual reports.
Fiscal year ends on December 31.

Note: The wholesale data include sales of passenger cars, light vehicles, and medium and heavy trucks.
Wholesale data include all Ford- and Lincoln-badged units (whether produced by Ford or by an unconsolidated affiliate) that are sold to dealerships, units manufactured by Ford that are sold to other manufacturers, units distributed for other manufacturers, and local brand units produced by the unconsolidated Chinese joint venture Jiangling Motors Corporation Ltd (JMC) that are sold to dealerships. Vehicles sold to daily rental car companies that are subject to a guaranteed repurchase option (rental repurchase), as well as other sales of finished vehicles for which the recognition of revenue is deferred (such as consignments), are also included in wholesale unit volumes.

**: Volvo, Jaguar Land Rover and Aston Martin when they still formed part of Ford

1.2.3.1.3. General Motors

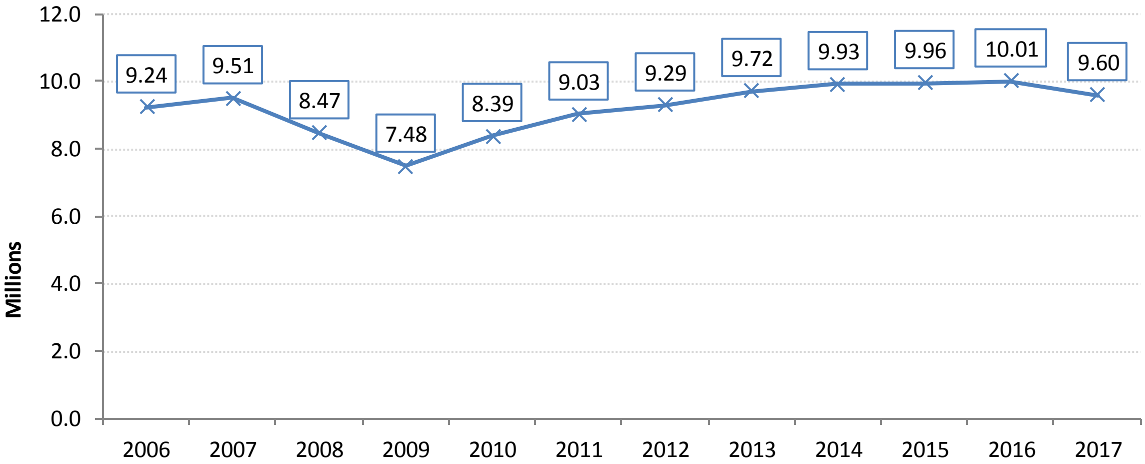
Figure 90
Total Revenue: GM



Sources: GM annual reports and ECB exchange rate data.
Fiscal year ends on December 31.

Note: Total revenues include net sales from GM automotive operations, as well as revenues from the company GM Financial, which provides financing services to customers, such as credit and lease financing, vehicle insurance and extended service contracts.

Figure 91
Total Unit Sales: GM

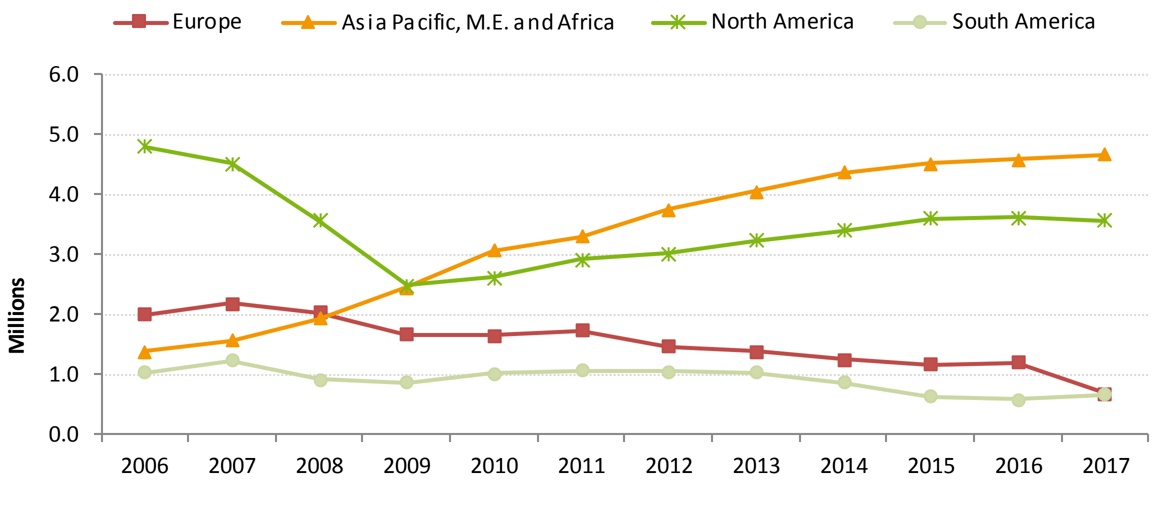


Sources: GM annual reports. Fiscal year ends on December 31.

Note: Retail sales include passenger cars, light commercial vehicles, heavy trucks, and heavy buses. Data on cars and trucks sold to fleet customers are also included in the retail sales data.

The retail sales data include sales by joint ventures on a total vehicle basis, not based on the percentage of ownership in the joint venture.

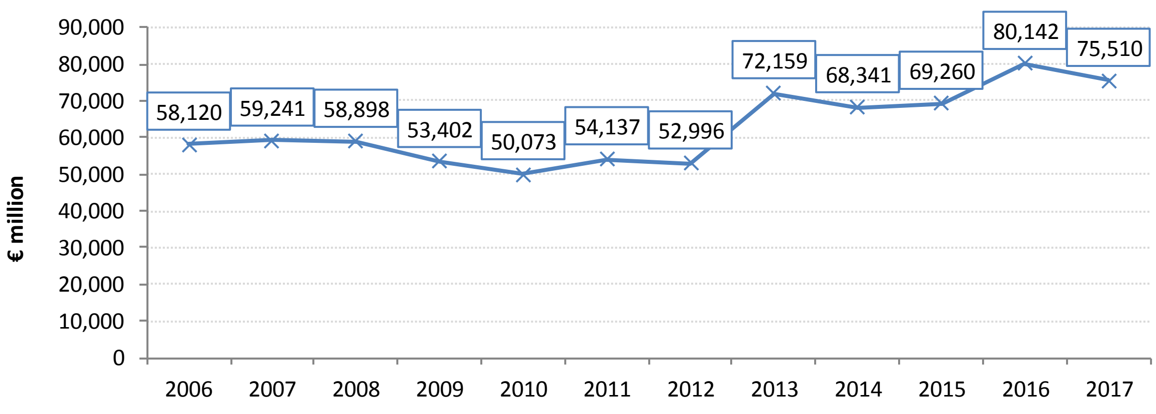
Figure 92
Unit Sales by Region: GM



Sources: GM annual reports. Fiscal year ends on December 31.
Note: Retail sales include passenger cars, light commercial vehicles, heavy trucks, and heavy buses. Data on cars and trucks sold to fleet customers are also included in the retail sales data.
The retail sales data include sales by joint ventures on a total vehicle basis, not based on the percentage of ownership in the joint venture.

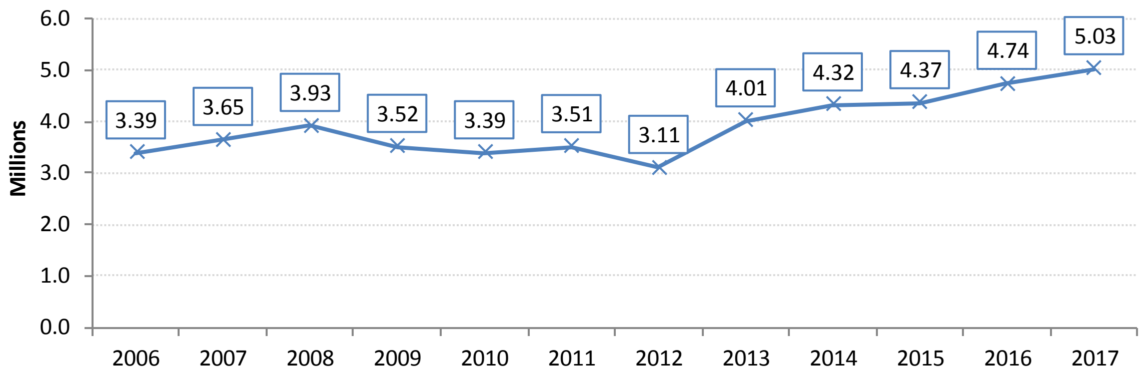
1.2.3.1.4. Honda

Figure 93
Total Revenue: Honda



Sources: Honda annual reports and ECB exchange rate data.
Fiscal year ends on March 31. Data exclude motorcycles.

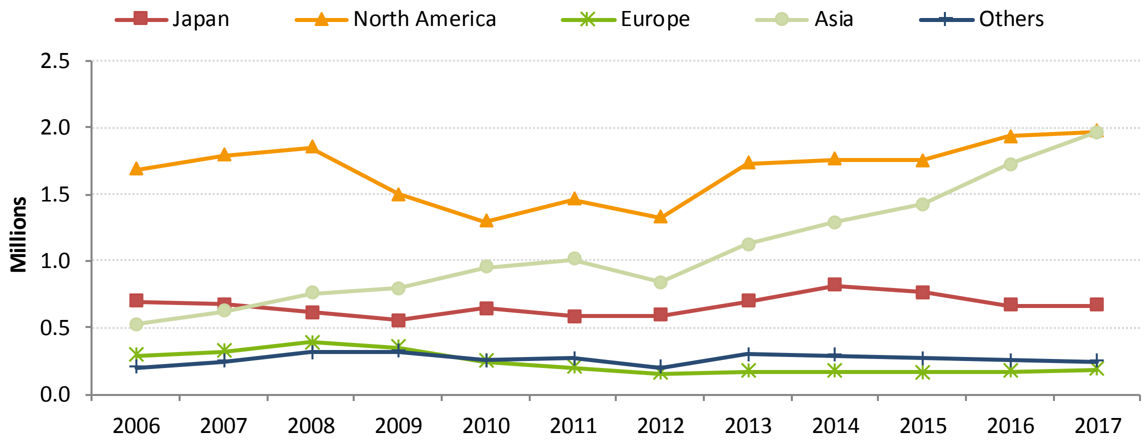
Figure 94
Total Unit Sales: Honda



Sources: Honda annual reports. Fiscal year ends on March 31. Data exclude motorcycles.

Note: Honda Group total sales include completed products of Honda, its consolidated subsidiaries and its affiliates. Vehicles sales include passenger cars and light vehicles but not motorcycles.

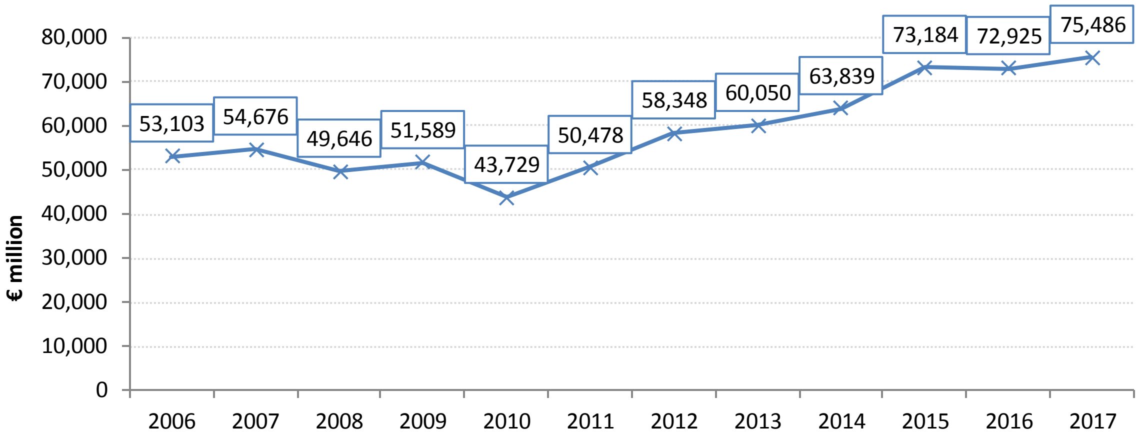
Figure 95
Unit Sales by Region: Honda



Sources: Honda annual reports. Fiscal year ends on March 31. Data exclude motorcycles.
Note: Honda Group total sales include completed products of Honda, its consolidated subsidiaries and its affiliates. Vehicles sales include passenger cars and light vehicles but not motorcycles.

1.2.3.1.5. Hyundai Motor Company

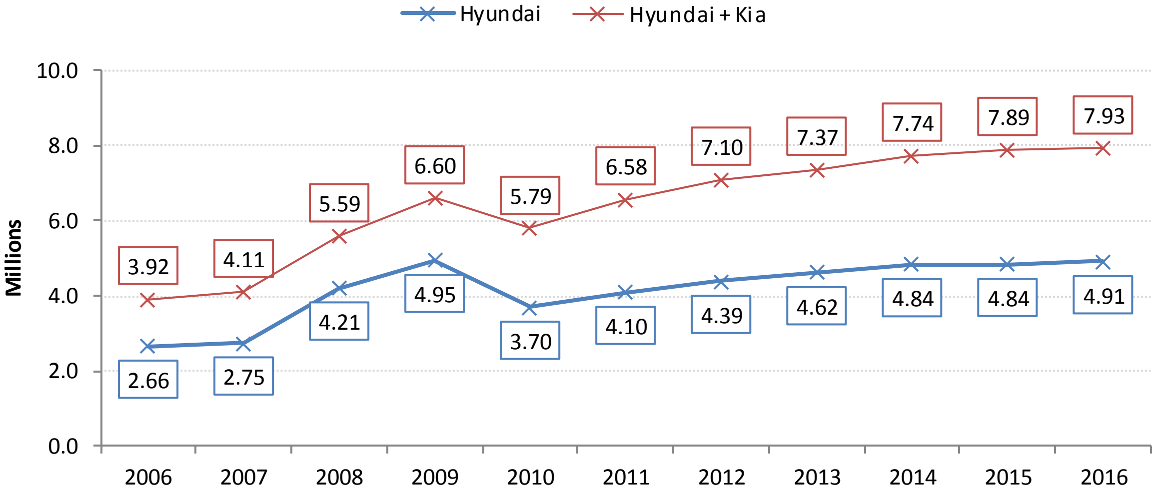
Figure 96
Total Revenue: Hyundai



Sources: Hyundai annual reports and ECB exchange rate data.
Fiscal year ends on December 31. Data do not include the Kia.

Note: Business results of joint ventures are accounted on an equity income basis.

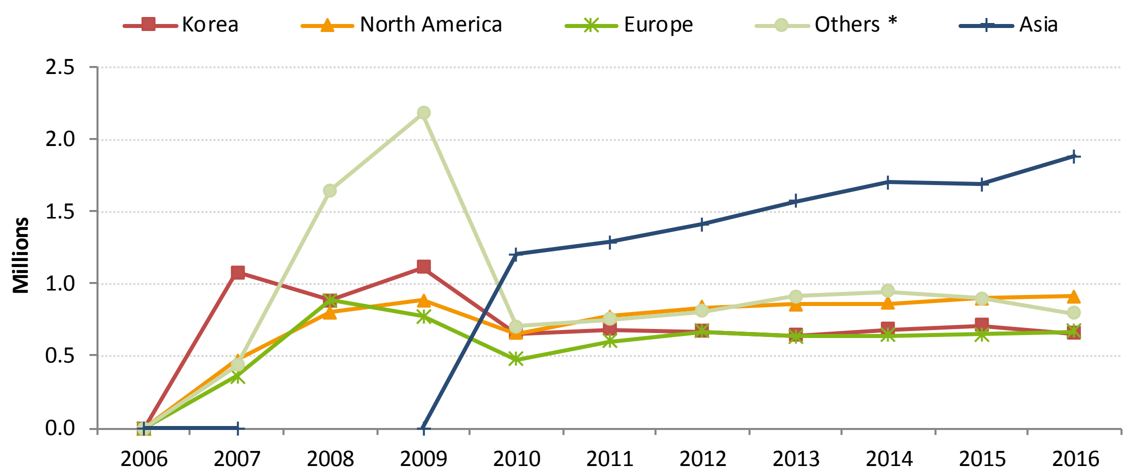
Figure 97
Total Unit Sales: Hyundai



Sources: Hyundai and Kia annual reports.
Fiscal year ends on December 31.

Note: Retail sales include passenger cars, recreational vehicles, and commercial vehicles.

Figure 98
Unit Sales by Region: Hyundai

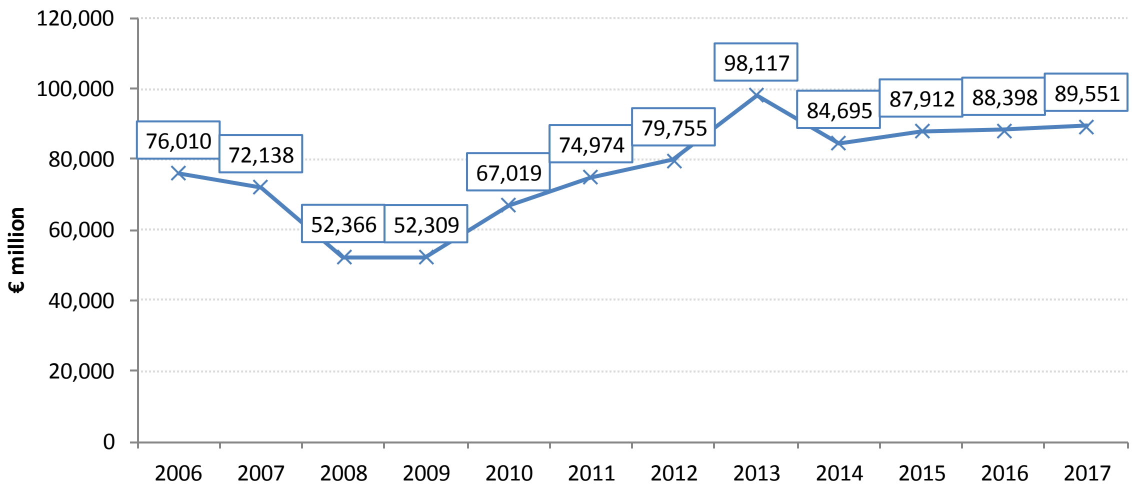


Sources: Hyundai annual reports.
Fiscal year ends on December 31. Kia not included.
Note: Retail sales include passenger cars, recreational vehicles, and commercial vehicles.

Others: Asia, Africa, Middle East, South America

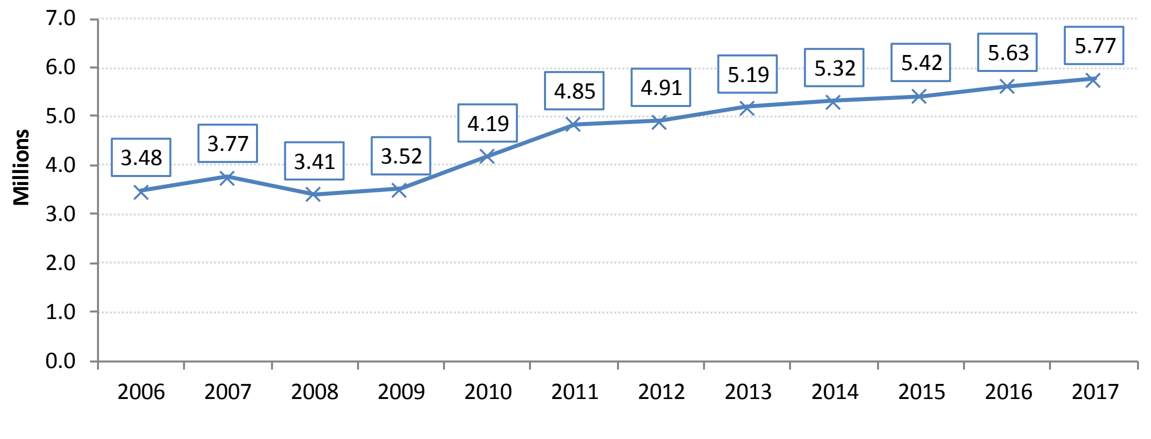
1.2.3.1.6. Nissan Motor Company

Figure 99
Total Revenue: Nissan



Sources: Nissan annual reports and ECB exchange rate data. Fiscal year ends on March 31.
Note: Revenues represent Nissan's consolidated net sales. Its Chinese joint venture is accounted on an equity basis.

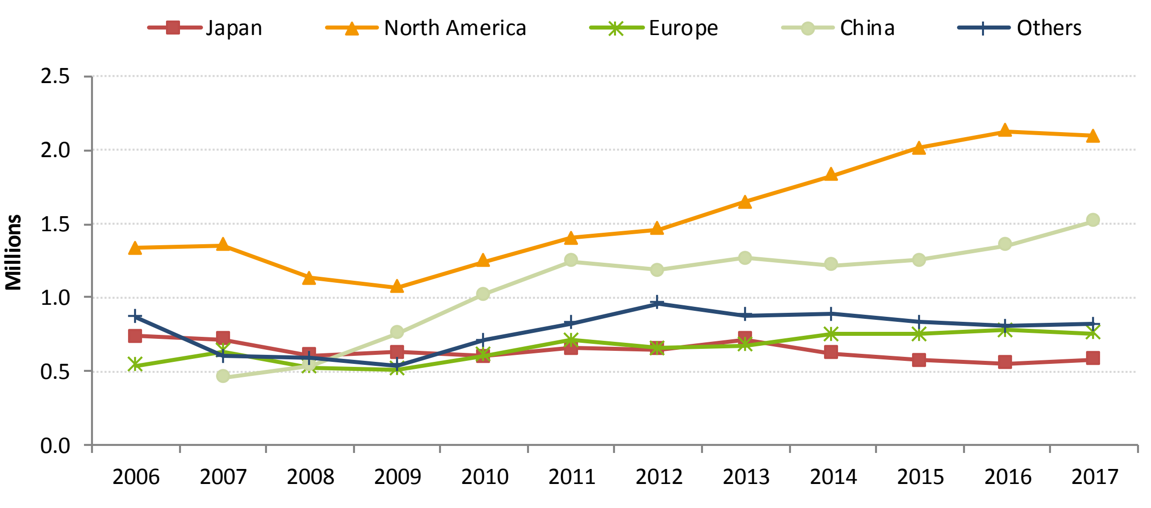
Figure 100
Total Unit Sales: Nissan



Sources: Nissan annual reports. Fiscal year ends on March 31.

Note: The retail sales data include sales of passenger cars, light vehicles, heavy trucks and heavy buses.

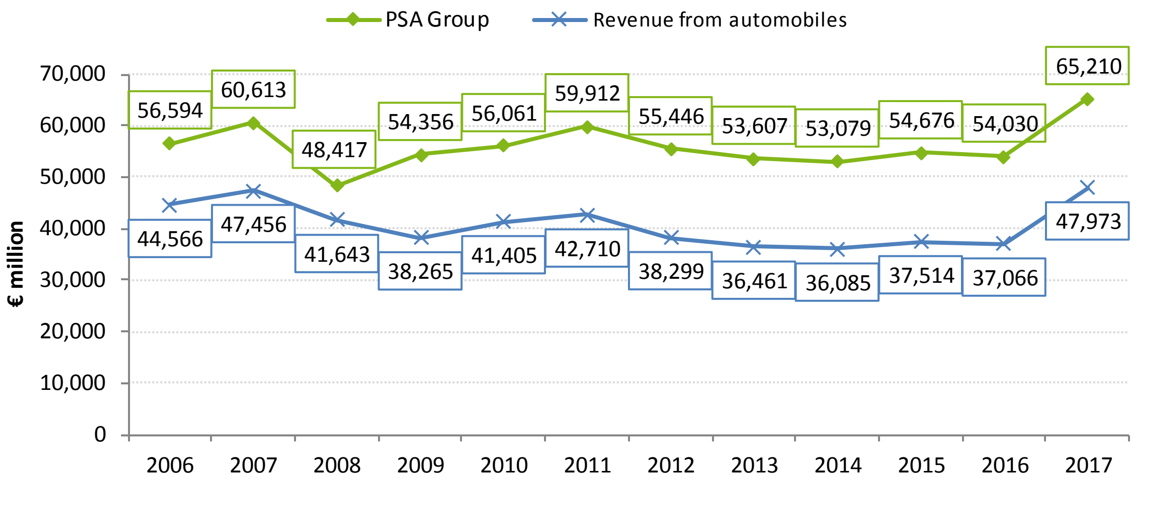
Figure 101
Unit Sales by Region: Nissan



Sources: Nissan annual reports. Fiscal year ends on March 31.
Note: The retail sales data include sales of passenger cars, light vehicles, heavy trucks and heavy buses.

1.2.3.1.7. PSA Group

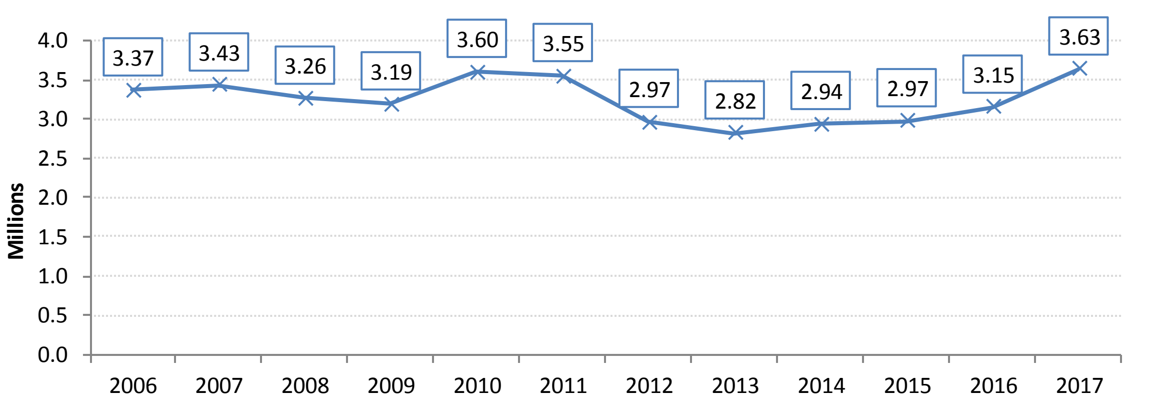
Figure 102
Total Revenue: PSA



Source: PSA annual reports. Fiscal year ends on December 31.

Note: The PSA Group includes revenue from Faurecia, Banque PSA Finance, and Gefco, among other businesses. In 2017, PSA acquired Opel Vauxhall. Opel Vauxhall automotive revenues totalled €7,238 million for the final five months of 2017.

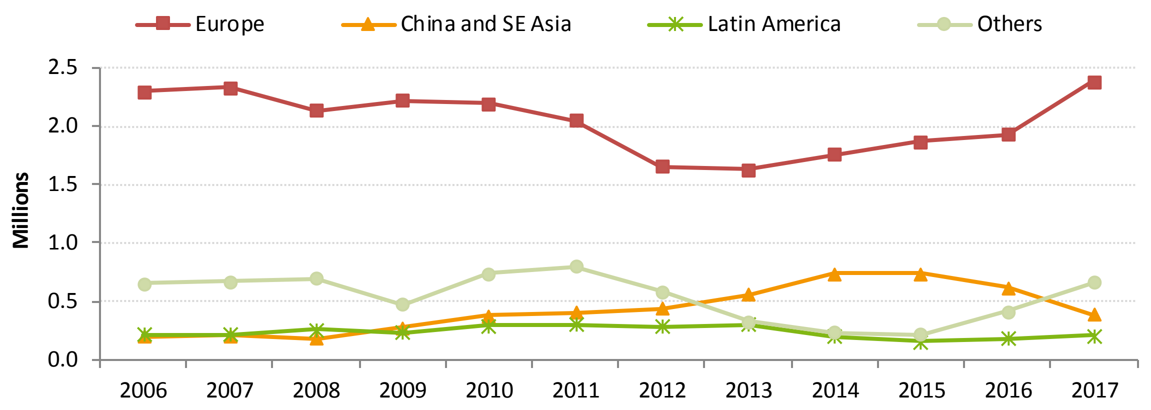
Figure 103
Total Unit Sales: PSA



Sources: PSA annual reports. Fiscal year ends on December 31.

Note: Unit sales include passenger cars and light commercial vehicles. In 2017, PSA acquired Opel Vauxhall.

Figure 104
Unit Sales by Region: PSA

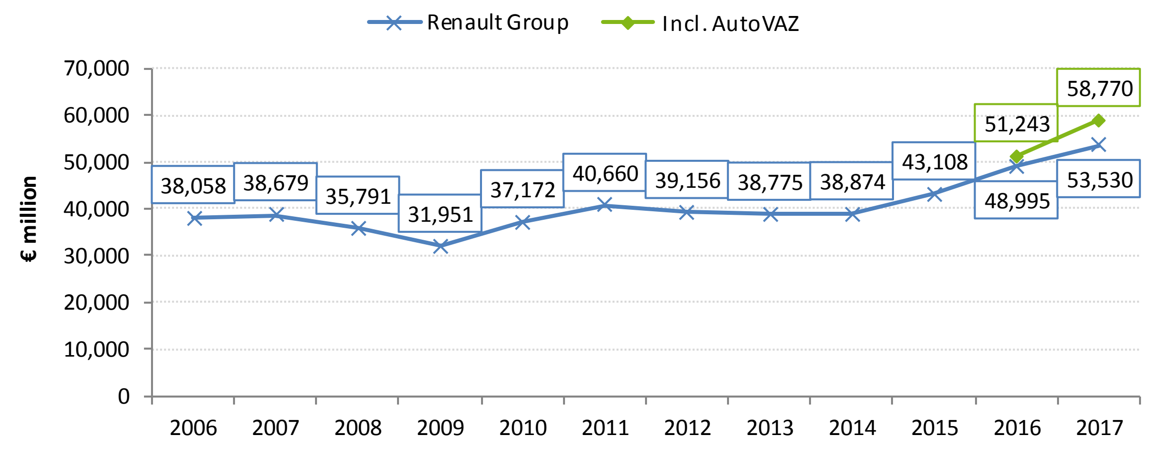


Sources: PSA annual reports. Fiscal year ends on December 31.

Note: Unit sales include passenger cars and light commercial vehicles.

1.2.3.1.8. Renault Group

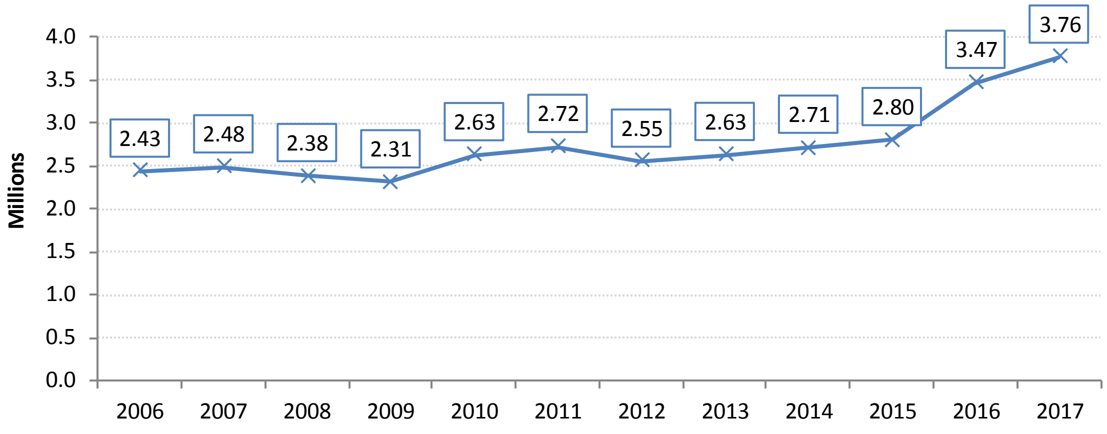
Figure 105
Total Revenue: Renault



Source: Renault annual reports. Fiscal year ends on December 31. Data do not include Nissan

Note: Unit sales include passenger cars and light commercial vehicles. In 2017, PSA acquired Opel Vauxhall

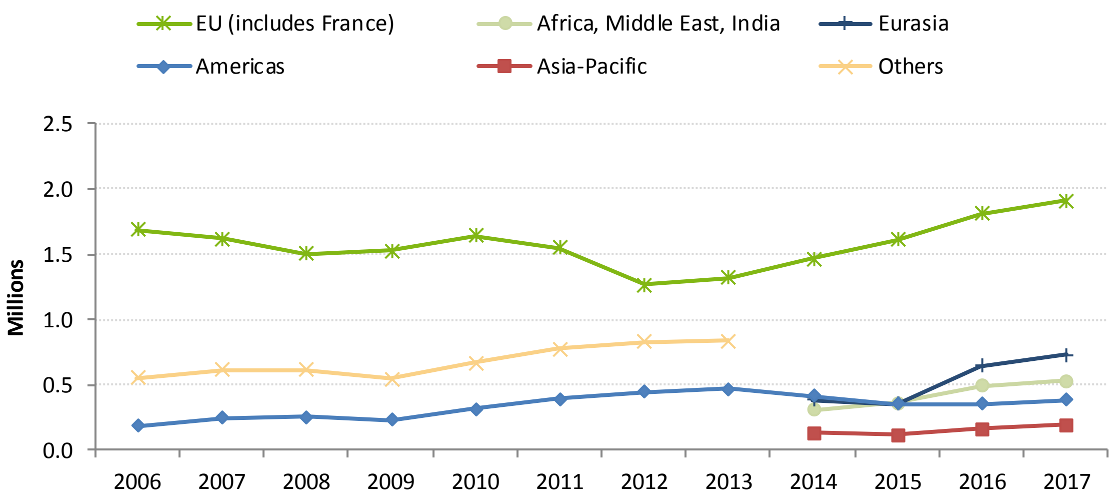
Figure 106
Total Unit Sales: Renault



Source: Renault annual reports. Fiscal year ends on December 31.
Data include Renault, Dacia, RSM and, since 2016, AvtoVAZ but exclude Nissan.

Note: Retail sales data include sales of passenger cars and light commercial vehicles.

Figure 107
Unit Sales by Region: Renault

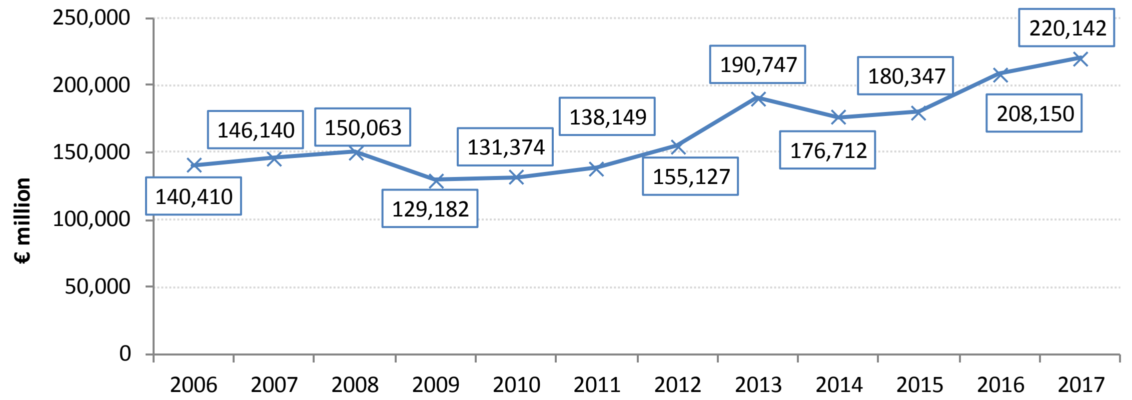


Sources: Renault annual reports. Fiscal year ends on December 31.
Data include Renault, Dacia, RSM and, since 2016, AvtoVAZ but exclude Nissan.

Note: Retail sales data include sales of passenger cars and light commercial vehicles.

1.2.3.1.9. Toyota Group

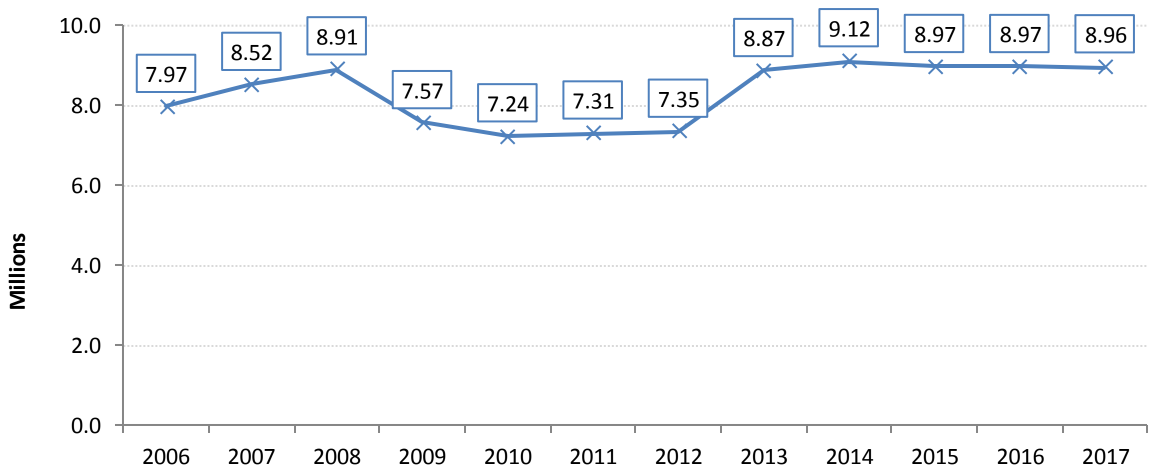
Figure 108
Total Revenue: Toyota



Sources: Toyota annual reports and ECB exchange rate data.
Fiscal year ends on March 31.

Note: Revenues refer to Toyota's automotive operations, including revenues from its consolidated subsidiaries. Revenues from Toyota's affiliates are accounted on an equity basis.

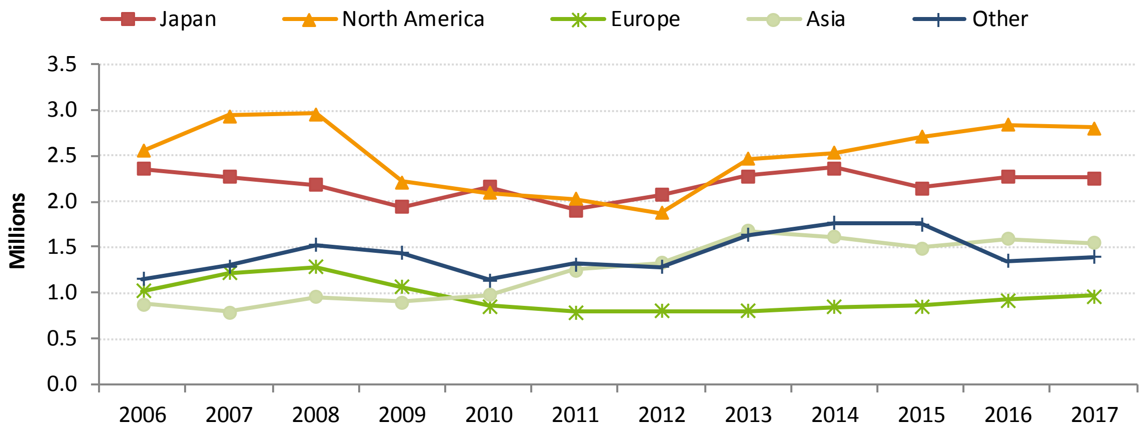
Figure 109
Total Unit Sales: Toyota



Sources: Toyota annual reports.
Fiscal year ends on March 31.

Note: The sales data include sales of the Toyota and Lexus brands. The data do not include Toyota's consolidated subsidiaries Daihatsu and Hino. The sales figures do not include Toyota's affiliates outside consolidation (such as joint-venture affiliates in China).

Figure 110
Unit Sales by Region: Toyota

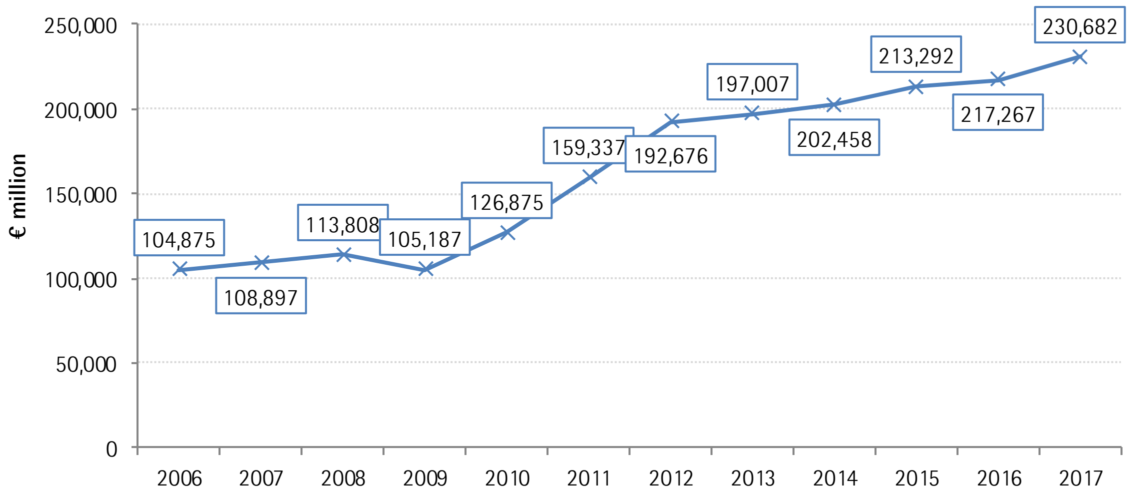


Sources: Toyota annual reports.
Fiscal year ends on March 31.

Note: The sales data include sales of the Toyota and Lexus brands. The data do not include Toyota's consolidated subsidiaries Daihatsu and Hino. The sales figures do not include Toyota's affiliates outside consolidation (such as joint-venture affiliates in China).

1.2.3.1.10. Volkswagen Group

Figure 111
Total Revenue: VW Group

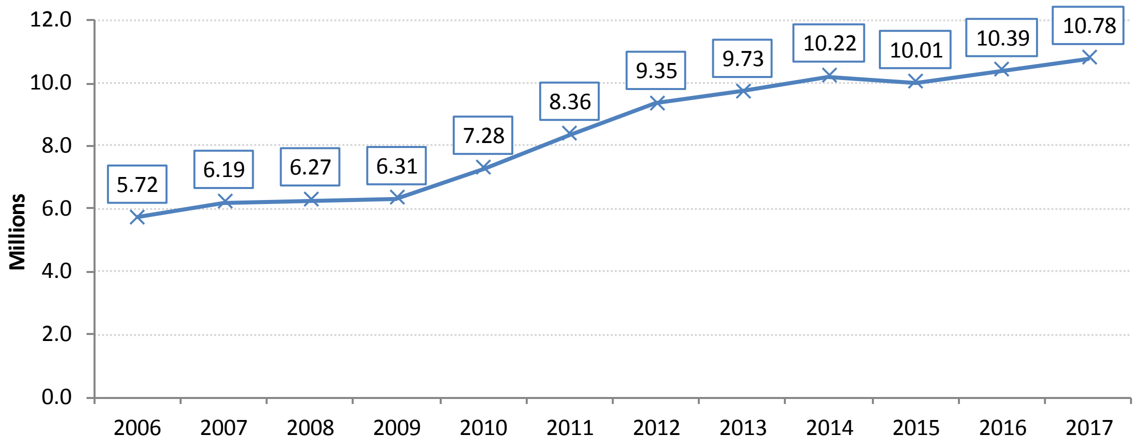


Sources: VW Group annual reports.
Fiscal year ends on December 31. All brands are included.

Note: Revenues include Volkswagen's automotive and financial services divisions. The latter combines dealer and customer financing, leasing, banking and insurance activities, fleet management and mobility offerings. Revenues include Chinese joint ventures only on an equity basis.

Figure 112

Total Unit Sales: VW Group

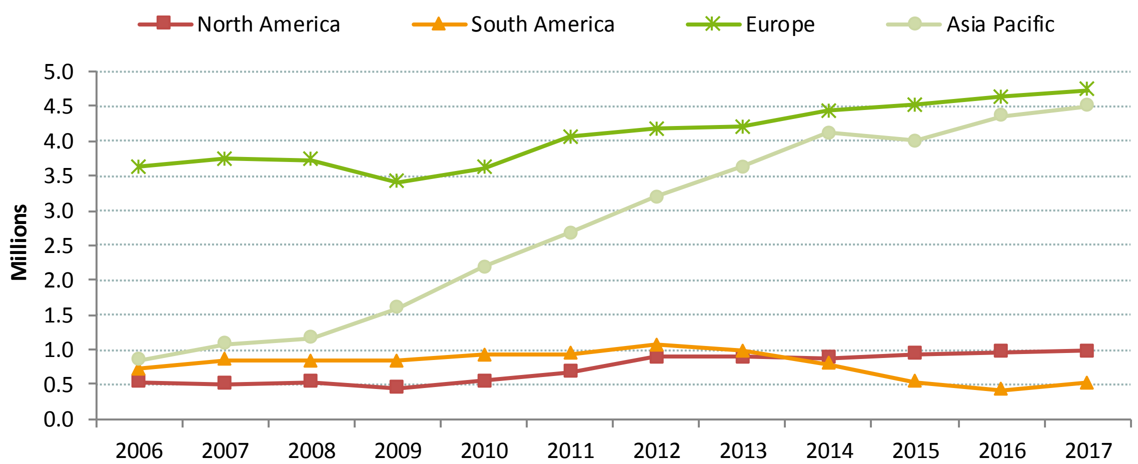


Sources: VW Group annual reports.
Fiscal year ends on December 31. All brands are included.

Note: The sales data include sales from VW Chinese joint ventures. The data include passenger cars, light commercial vehicles, heavy trucks and heavy buses.

Figure 113

Unit Sales by Region: VW Group



Sources: VW Group annual reports.
Fiscal year ends on March 31. All brands are included.

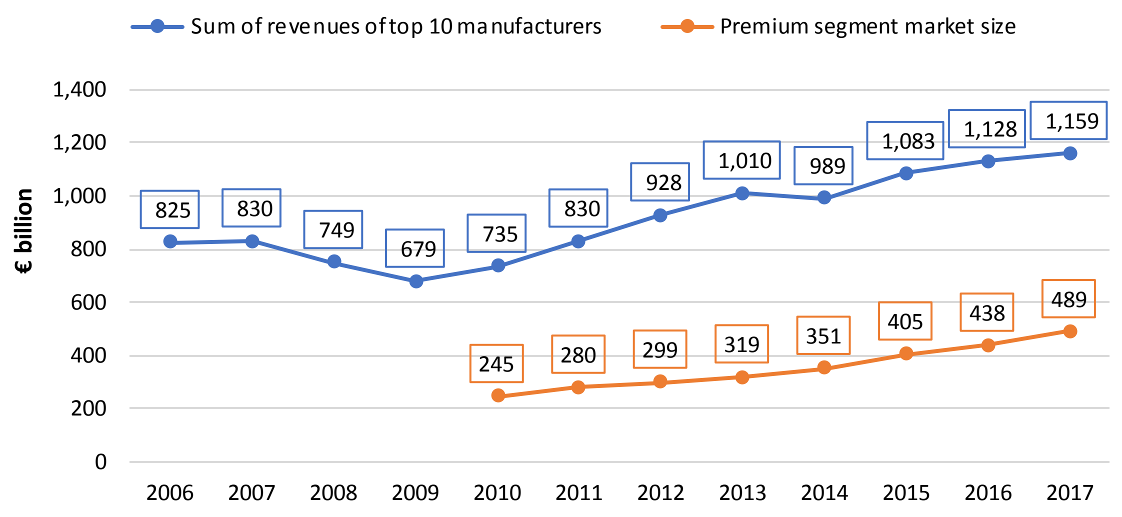
Note: The sales data include sales from VW Chinese joint ventures. The data include passenger cars, light commercial vehicles, heavy trucks and heavy buses.

1.2.3.2. Premium Segment

In 2017, the global premium-car market increased by about 12% from the previous year to reach €489 billion, while the revenues of the top 10 automotive groups grew by 3%.

Figure 114

Global Automotive and Premium Segment Market Size

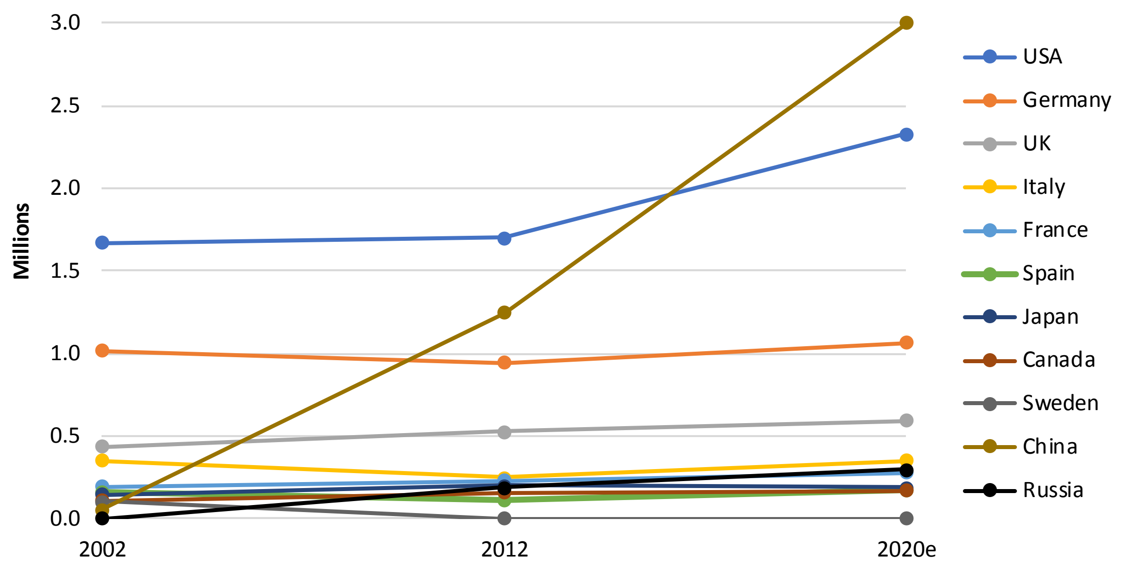


Sources: Top 10 manufacturers' revenue data from annual reports of FCA, Ford, GM, Honda, Hyundai Kia, Nissan, PSA, Renault, Toyota, and the VW Group. Premium segment market size data from Statista (2018).
LINK: https://www.statista.com/statistics/281574/size-of-the-luxury-car-market/

Growth of the premium-car segment was driven mainly by rising demand from increasingly affluent buyers in emerging markets, especially in China.

The premium-car segment in China increased at an impressive rate of 36% a year in a decade (2002–12), faster than the 26% annual growth rate in the overall Chinese passenger vehicle market during the same period. According to McKinsey (2013), premium-car sales in China could reach 3 million units by 2020, equaling those of Western Europe, and surpassing the 2.3 million sales expected in the US market.

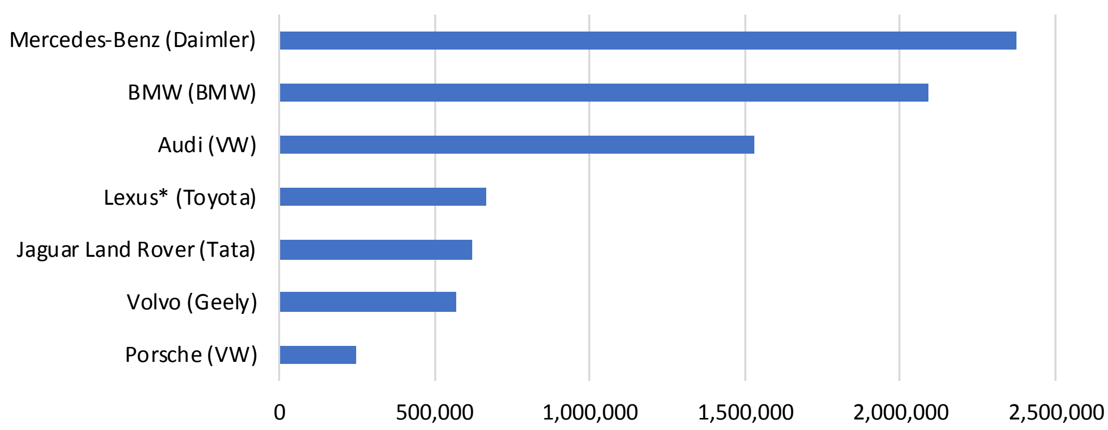
Figure 115
Global Premium-Car Sales (in Units)



Source: McKinsey (2013). Estimated values for 2020.

The leading premium-car manufacturers are the German brands Mercedes, BMW, and Audi.

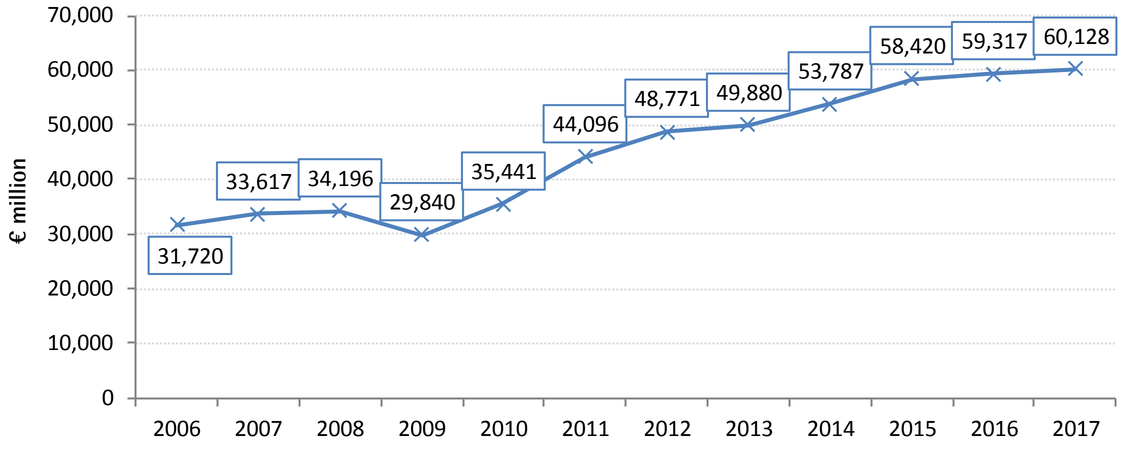
Figure 116
Premium Vehicles: 2017 Global Sales by Brand (in Units)



Sources: Companies' 2017 annual reports.
* Latest data available for Lexus: 2016.

1.2.3.2.1. Audi (Volkswagen Group)

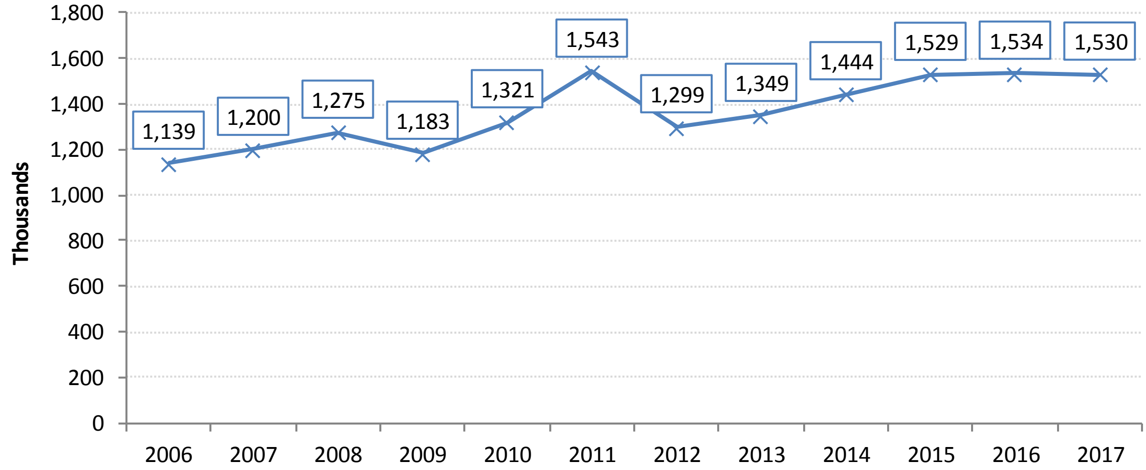
Figure 117
Total Revenue: Audi



Sources: VW Group annual reports.
Fiscal year ends on December 31.

Note: The sales data do not include Audi sales by the Chinese joint venture FAW-Volkswagen.

Figure 118
Total Unit Sales: Audi

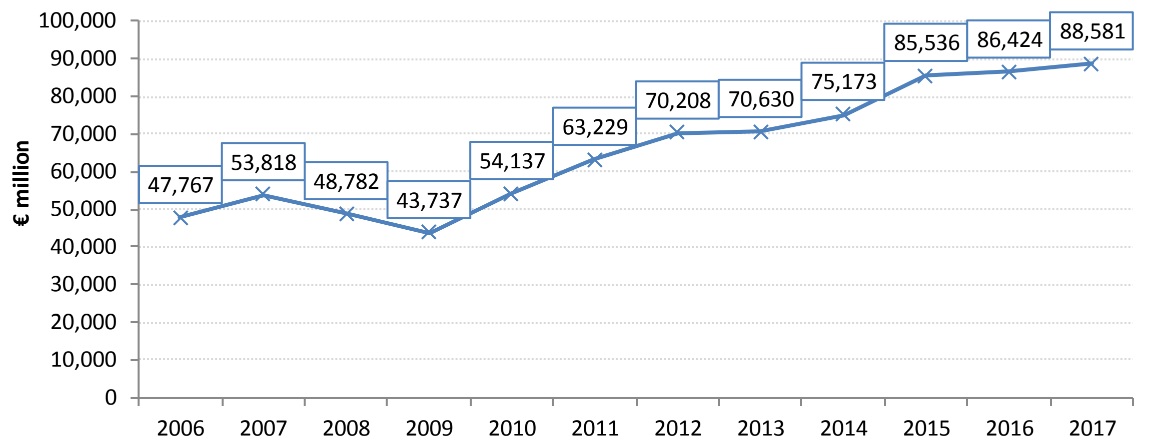


Sources: VW Group annual reports.
Fiscal year ends on December 31.

Note: The sales data do not include Audi sales by the Chinese joint venture FAW-Volkswagen.

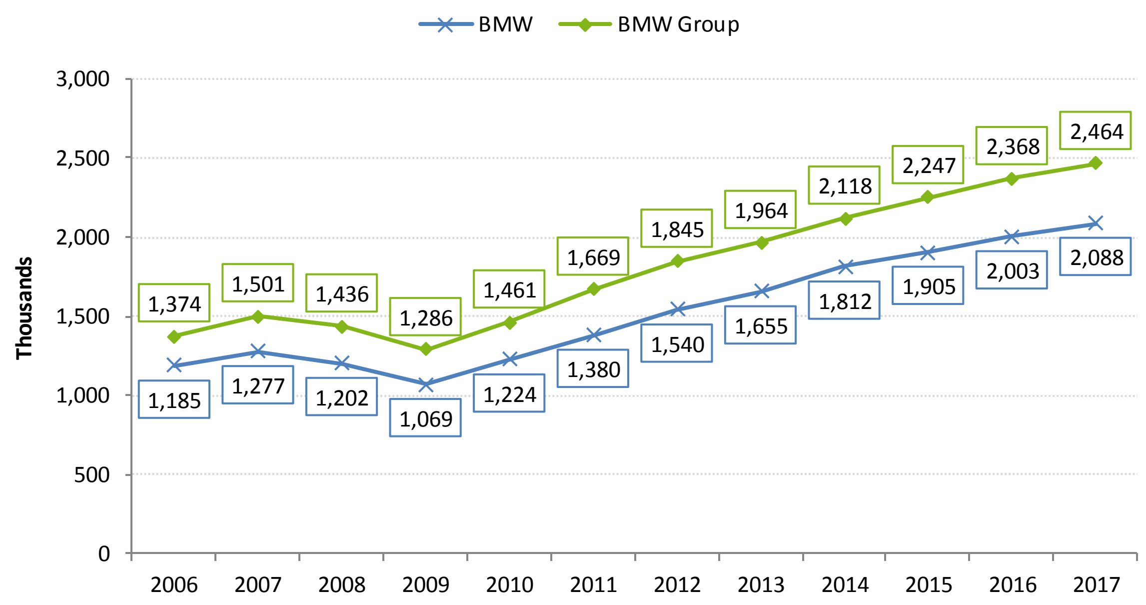
1.2.3.2.2. BMW Group

Figure 119
Total Revenue: BMW



Sources: BMW Group annual reports. Fiscal year ends on December 31.
The Mini and Rolls-Royce are included.
Motorcycles and financial services are excluded.

Figure 120
Total Unit Sales: BMW



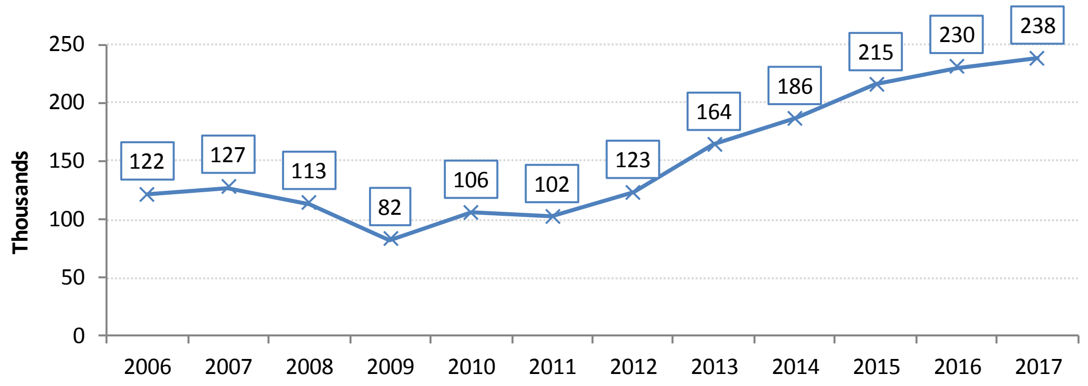
Sources: BMW Group annual reports.
Fiscal year ends on December 31.

Note: The BMW Group data include the Mini and Rolls-Royce. The BMW and BMW Group data include sales from the joint venture BMW Brilliance Automotive Ltd. in Shenyang, China, for the years since 2010.

1.2.3.2.3. Infiniti (Nissan Motor Company)

Total revenue data not available.

Figure 121
Total Unit Sales: Infiniti



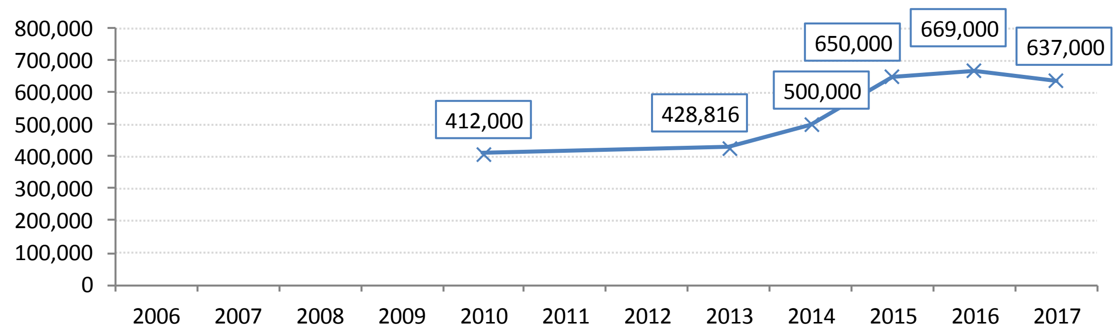
Source: Infiniti website.
Fiscal year ends on December 31.

Note: US and Europe sales only for 2006 to 2013.
Source: http://infinitinews.com/en-US/infiniti/usa/channels/Sales-Reports-Infiniti-US

1.2.3.2.4. Lexus (Toyota Group)

Total revenue data not available.

Figure 122
Total Unit Sales: Lexus

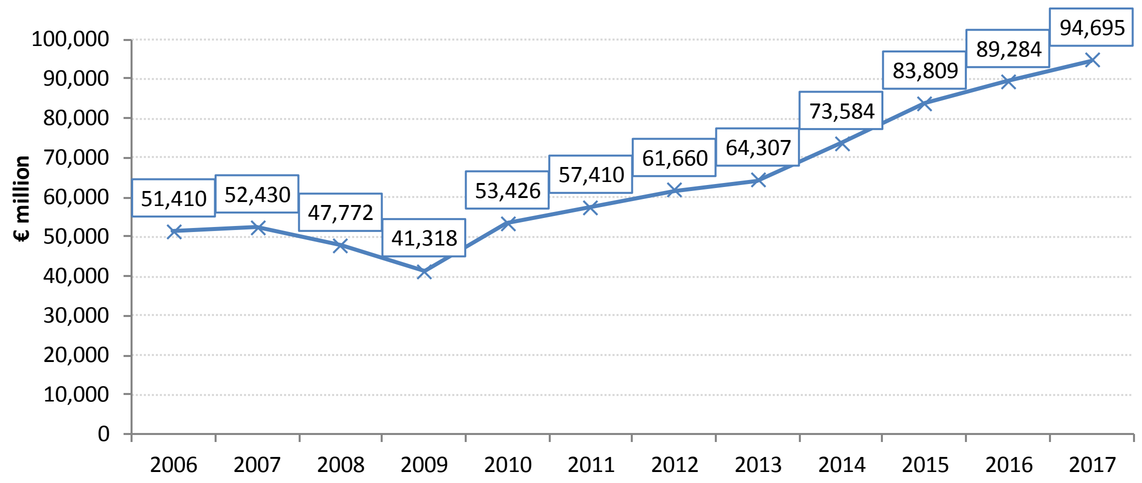


Source: Focus2move.com.
Fiscal year ends on March 31.

Note: Data are unavailable for 2006 to 2009 as well as for 2011 and 2012. Source: Toyota USA Newsroom (https://pressroom.toyota.com/)

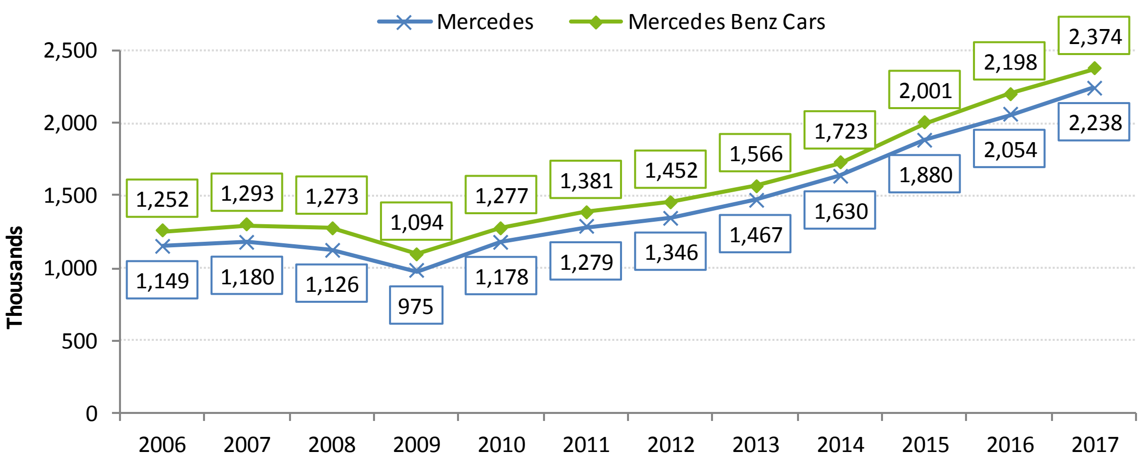
1.2.3.2.5. Mercedes (Daimler Group)

Figure 123
Total Revenue: Mercedes



Sources: Daimler Group annual reports.
Fiscal year ends on December 31.
Note: The revenue data refer to Mercedes-Benz cars, including the Smart, but not to vans and trucks.

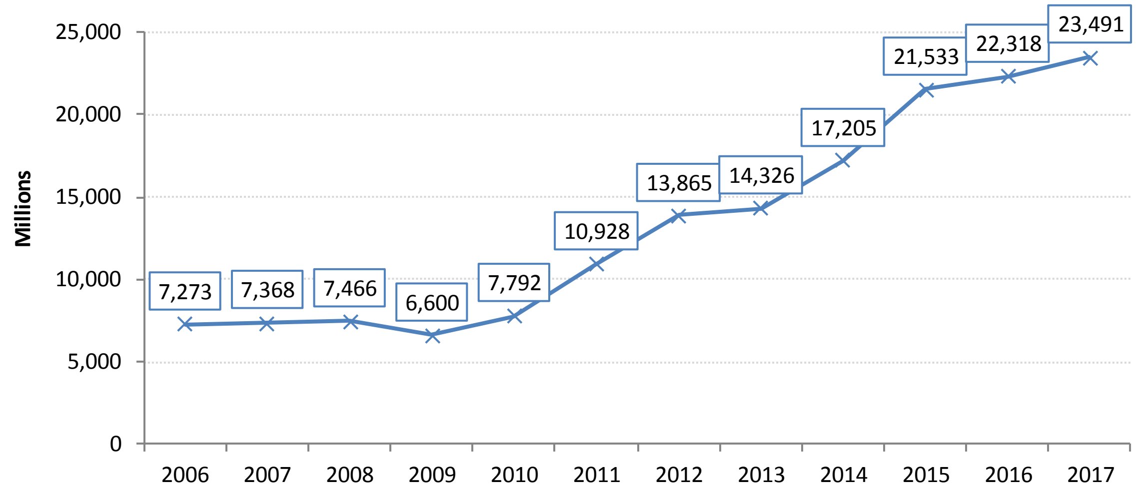
Figure 124
Total Unit Sales: Mercedes



Sources: Daimler Group annual reports.
Fiscal year ends on December 31.
Note: The Mercedes-Benz cars division includes the Mercedes, AMG, Maybach, Smart, and Mercedes Me brands.

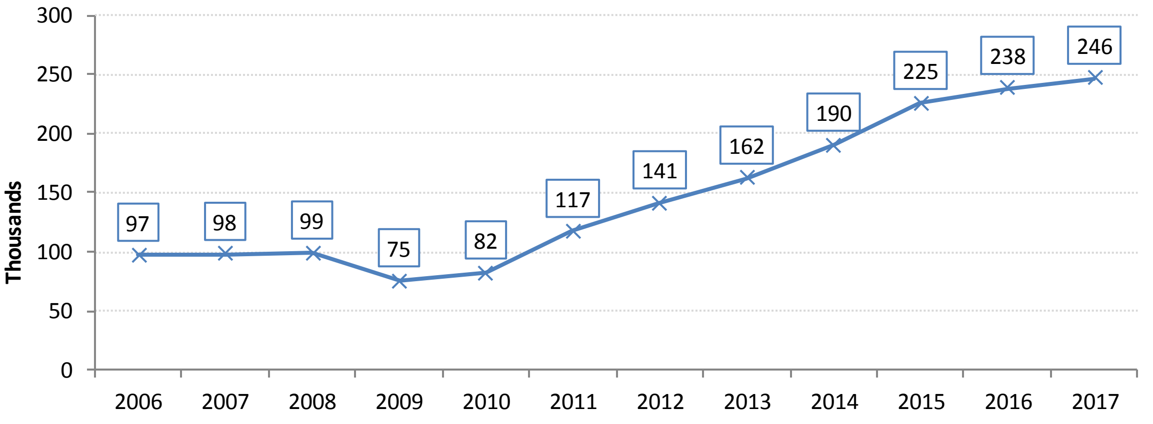
1.2.3.2.6. Porsche

Figure 125
Total Revenue: Porsche



Sources: Porsche annual reports.
Fiscal year ends on December 31.

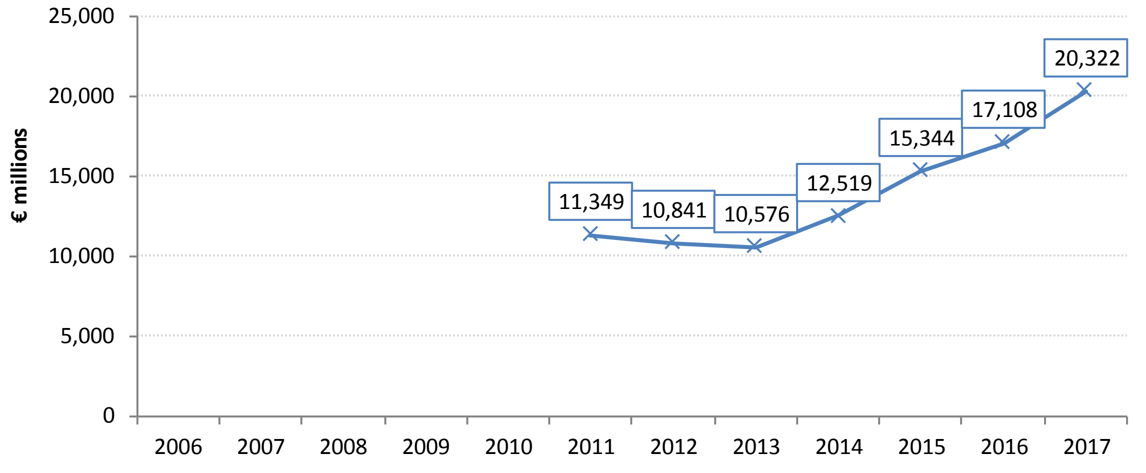
Figure 126
Total Unit Sales: Porsche



Sources: Porsche annual reports.
Fiscal year ends on December 31.

1.2.3.2.7. Volvo

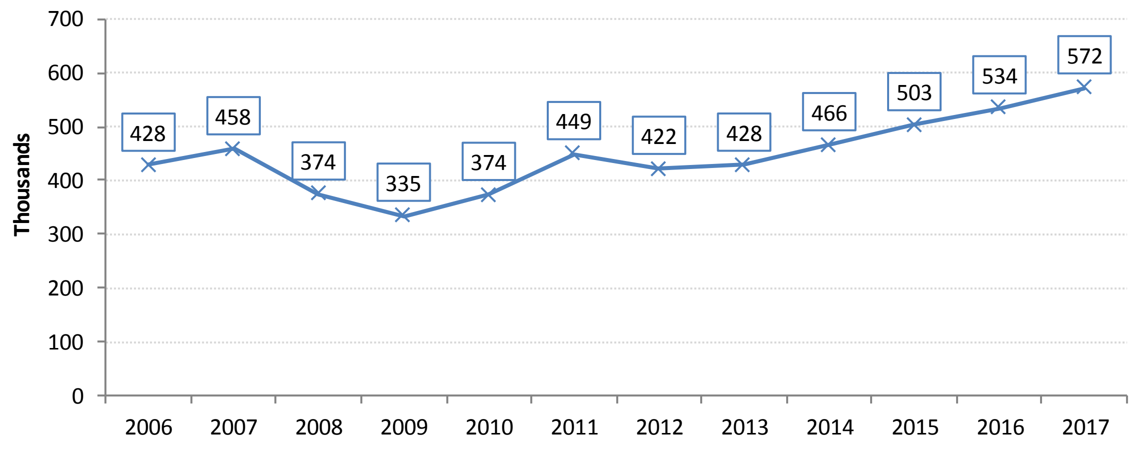
Figure 127
Total Revenue: Volvo



Sources: Volvo annual reports and ECB exchange rate data.
Fiscal year ends on December 31.

Note: Total revenue data are unavailable for 2006 to 2010.

Figure 128
Total Unit Sales: Volvo



Sources: Volvo annual reports.
Fiscal year ends on December 31.

1.3. International Trade

This section analyzes international trade in the automobile sector by the main region and by top manufacturing country. Data on trade in value (in euros) were collected from the UN Comtrade database. Data on trade in volume (units of vehicles) were collected from OICA. As of May 2018, the latest available data are from the year 2016.

It is worth clarifying that *net exports/net imports* refer to the result of the trade balance (value of exports minus value of imports).

As for the term *net production*, this is the result of subtracting domestic sales from total units produced (units produced minus units sold domestically). Net production is used as a proxy for the number of units exported or imported. Therefore, if a country has positive net production, this means that it exports more units than it imports. If a country has negative net production, this means that it imports more units than it exports.

1.3.1. Regions

The automotive industry plays a major role in global international trade. In 2016, world exports of total motor vehicles amounted to €815.1 billion. This number represents an increase of 3.3% compared to the 2015 figure (€788.8 billion), and accounts for 5.8% of global merchandise exports (€13.943 trillion). World exports of passenger cars amounted to €632.5 billion.

According to Eurostat, in the segment of motor vehicles, the European Union emerged as a net car exporter in 2016, with a trade surplus of €128.2 billion. Extra EU exports of motor vehicles totaled €192.0 billion, while imports reached a value of €77.0 billion. In 2016, the United States remained the number one partner for extra-EU exports with a share of 25%. China was the second export market for EU cars (16%), followed by Turkey (7%) and Switzerland (5%). These four countries, together with South Korea, Japan, and Russia, bought around 66% of EU car exports in 2016. As in previous years, Germany was responsible for more than half the total of extra-EU car exports. It was also the largest importer of motor vehicles in 2016: about a quarter of the total value of extra-EU imports can be ascribed to Germany[34].

The United States ended 2016 as a net car importer. Passenger car exports from the United States totaled €48.7 billion in 2016, while imports totaled €156.6 billion. As a result, the country incurred a trade deficit. The United States represented 25% of that year's global car imports (UN Comtrade, trade data; OEC, trade data).

China also emerged as a net car importer in 2016. Chinese exports of passenger cars totaled €5.0 billion in 2016, while imports totaled €41.8 billon. China's trade deficit can strike us as surprising at first, considering that China is number one in the ranking of manufacturing countries. However, China is a net car importer in terms of value but a net car exporter in terms of units. This is due to the very varied markets in which China trades. The majority of cars exported by China are oriented to the mass market. Chinese imports, in contrast, lie more in the premium segment (UN Comtrade, trade data; OEC, trade data).

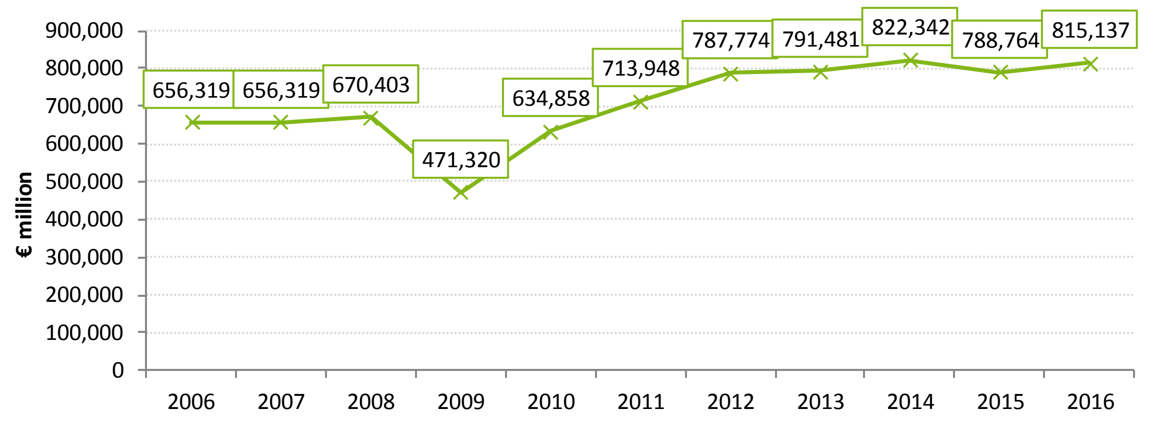
[34] Eurostat, trade data; ECB, exchange rate data
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_trade_in_goods_-_a_statistical_picture

As for Japan, the country ended 2016 as a net passenger-car exporter, with a trade surplus of €81.6 billion. Japanese exports totaled €77.5 billion that year (UN Comtrade, trade data; OEC, trade data).

In the following graphs, we will follow the UN Comtrade Standard International Trade Classification Revision 4 definitions. The term *passenger car* in this section refers to code 781: "motor cars and other motor vehicles principally designed for the transport of persons [...], including station-wagons and racing cars." This definition excludes motor vehicles for the transport of goods, motor vehicles for the transport of 10 or more people (including the driver), road tractors, semitrailers, and trailers. The term *motor vehicle* in the following sections refers to code 78, excluding codes 784 and 785: so the term covers all types of motor road vehicles other than motorcycles, with auto parts and accessories also being excluded (UN Comtrade, commodity definitions).

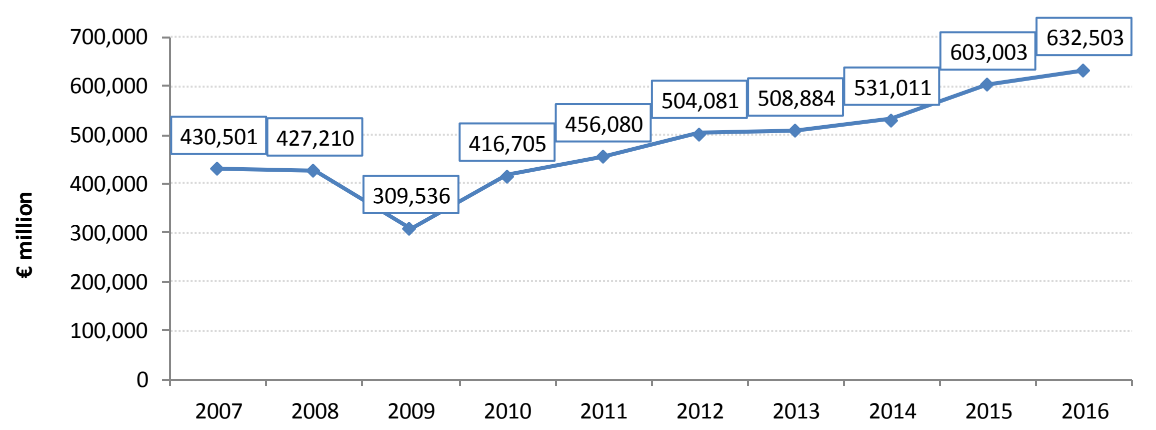
1.3.1.1. Worldwide Exports

Figure 129
Exports of Motor Vehicles Worldwide



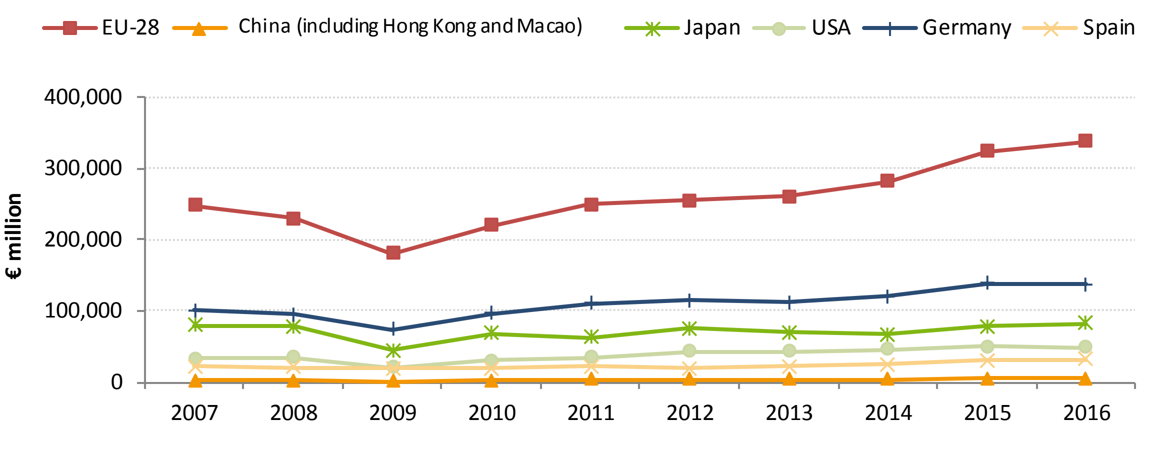
Source: UN Comtrade, trade data; ECB, exchange rate data.

Figure 130
Exports of Passenger Cars Worldwide



Source: UN Comtrade, trade data; ECB, exchange rate data.

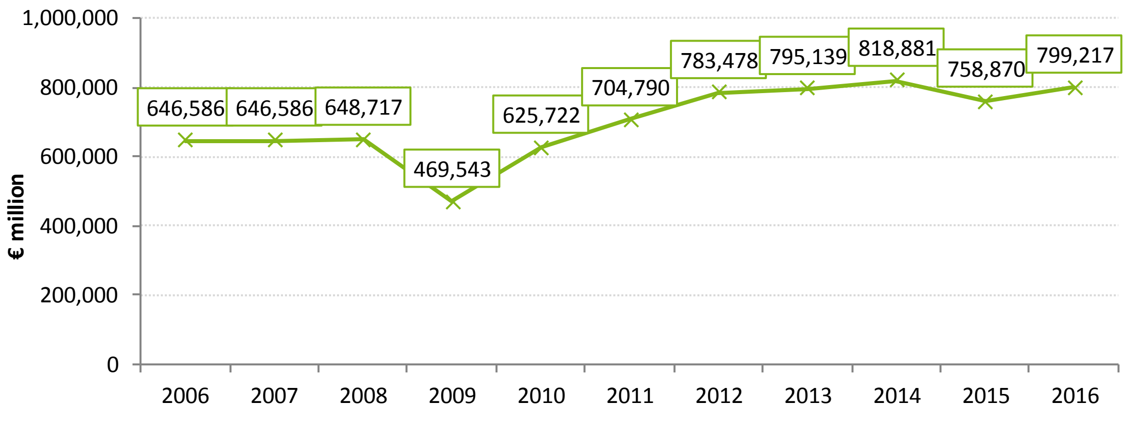
Figura 131
Exports of Passenger Cars by Top Region



Sources: UN Comtrade, trade data; Eurostat, trade data; ECB, exchange rate data.

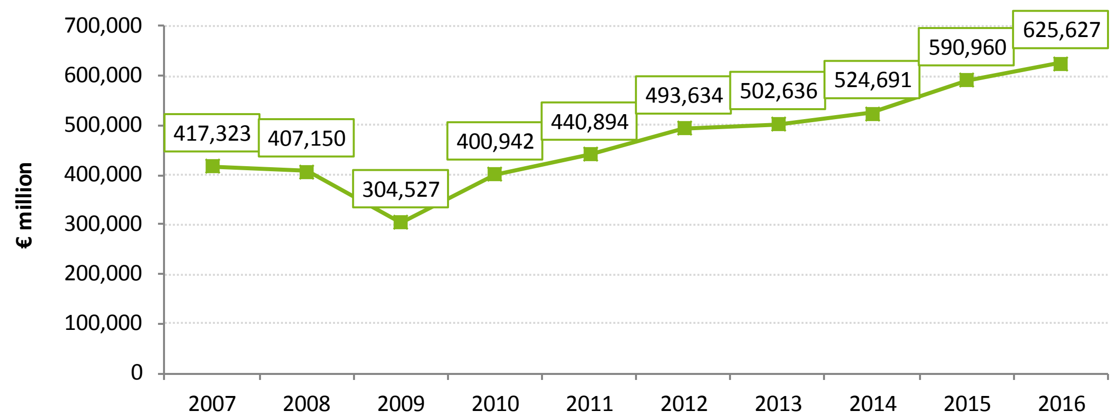
1.3.1.2. Worldwide Imports

Figure 132
Imports of Motor Vehicles Worldwide



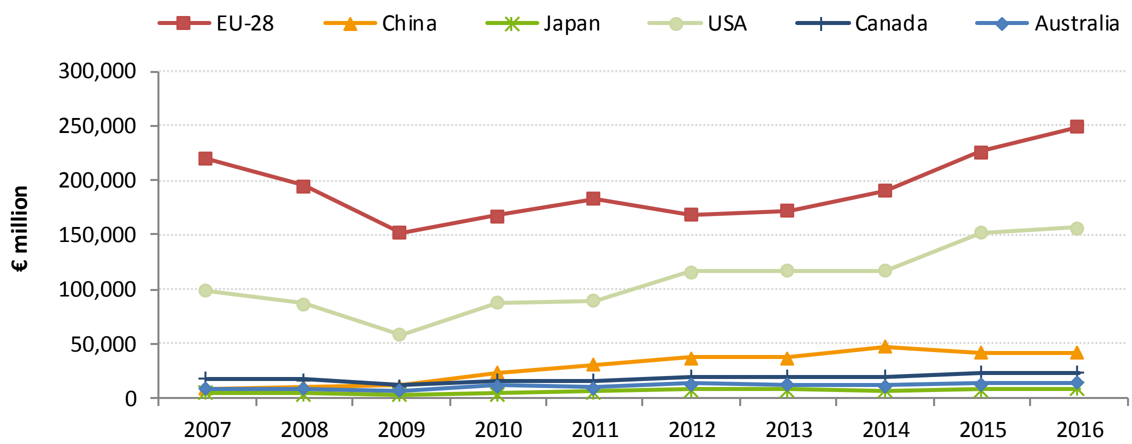
Source: UN Comtrade, trade data; ECB, exchange rate data.

Figure 133
Imports of Passenger Cars Worldwide



Source: UN Comtrade, trade data; ECB, exchange rate data.

Figure 134
Imports of Passenger Cars by Top Region



Sources: UN Comtrade, trade data; Eurostat, trade data; ECB, exchange rate data.

1.3.2. Countries

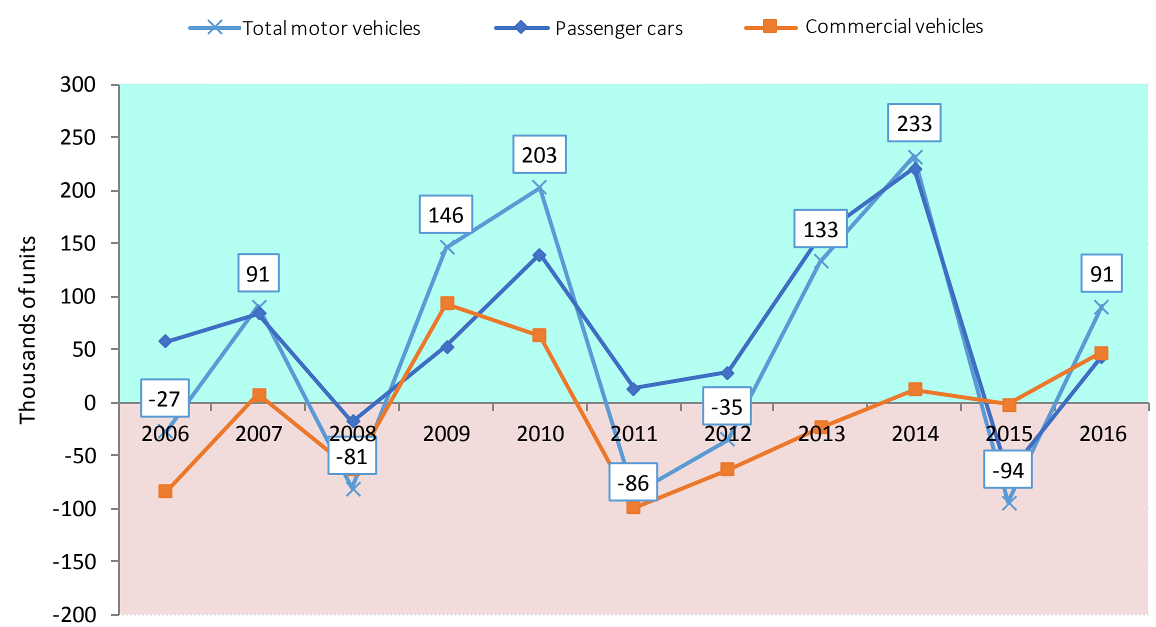
The following charts show the trade in units and in value.

Net production of vehicles for the main vehicle-manufacturing countries is the result of subtracting domestic sales from total units produced (units produced minus units sold domestically). Values are shown in units. The figure for net production is used as a proxy for the number of units exported or imported. That is, if a country has positive net production, this means that it exports more units than it imports. If a country has negative net production, this means that it imports more units than it exports.

The figure for net exports of vehicles refers to the trade balance. It is the difference between exports and imports (value of exports minus value of imports). Values are shown in euros (ECB data, for conversión).

1.3.2.1. China

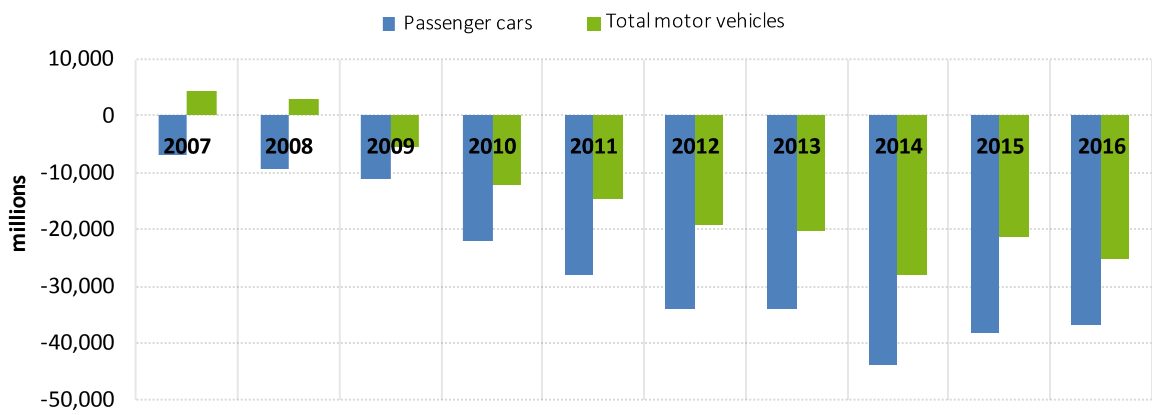
Figure 135
China: Net Production of Vehicles



Source: OICA, production and sales data.

Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

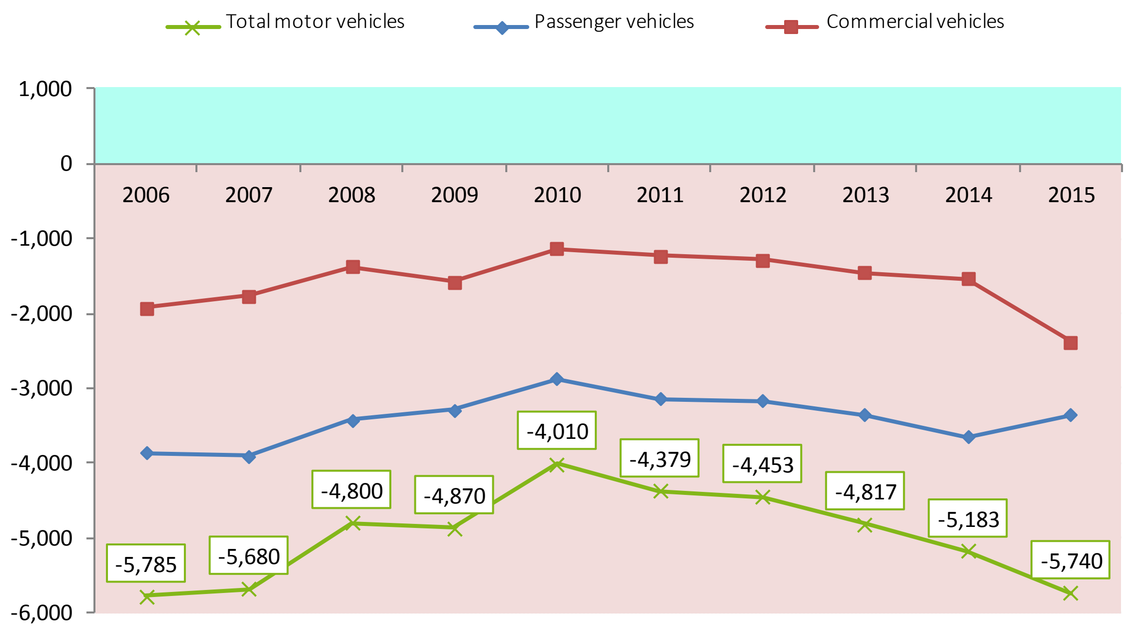
Figure 136
China: Net Exports of Vehicles (€ million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

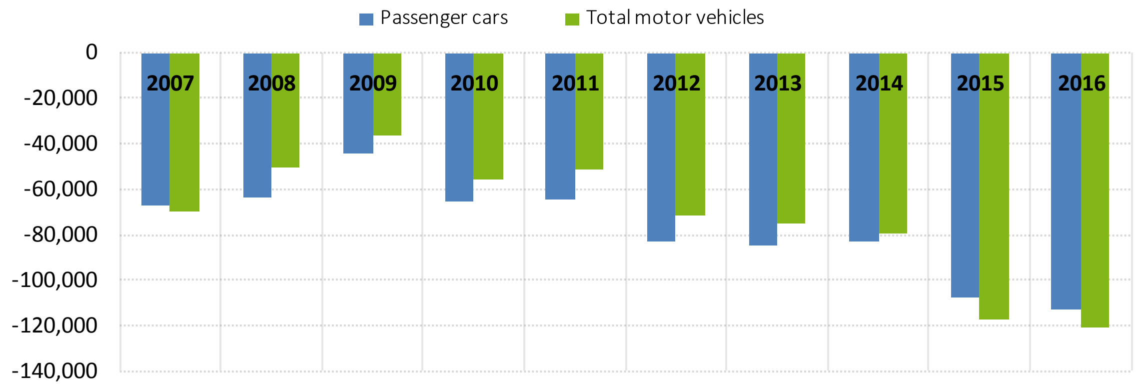
1.3.2.2. United States

Figure 137
United States: Net Production of Vehicles (in 1,000 Units)



Source: OICA production and sales data, for passenger cars and commercial vehicles; WardsAuto sales data and CAR sales data, for pickups.
Note: Passenger vehicles include passenger cars and pickups.
Commercial vehicles include light trucks (excluding pickups), heavy trucks, buses and coaches.

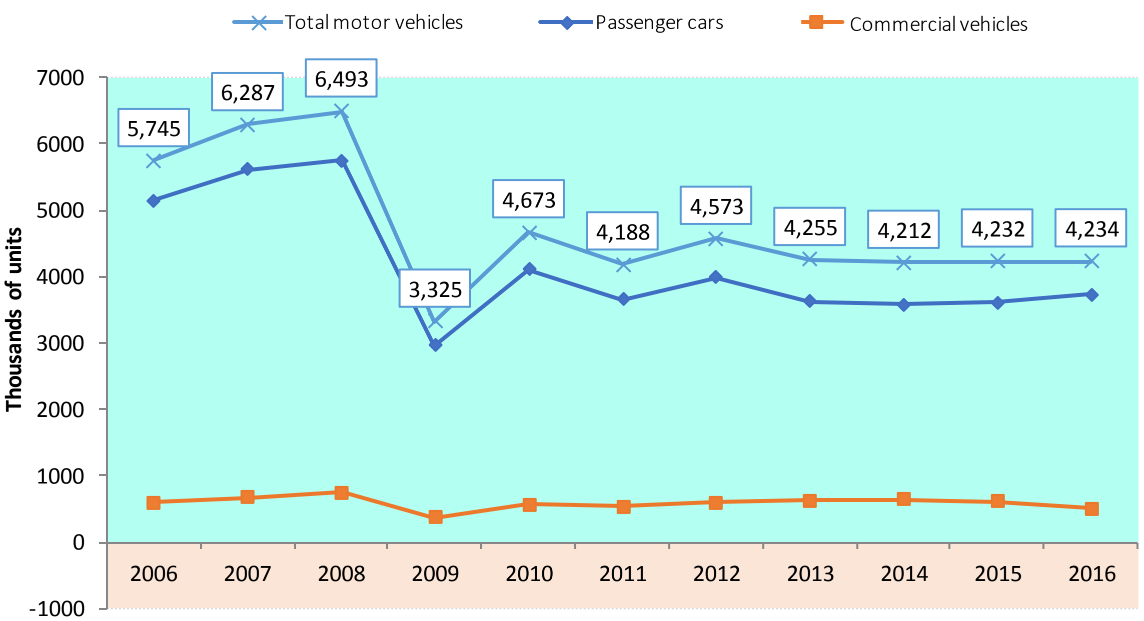
Figure 138
United States: Net Exports of Vehicles (in € million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

1.3.2.3. Japan

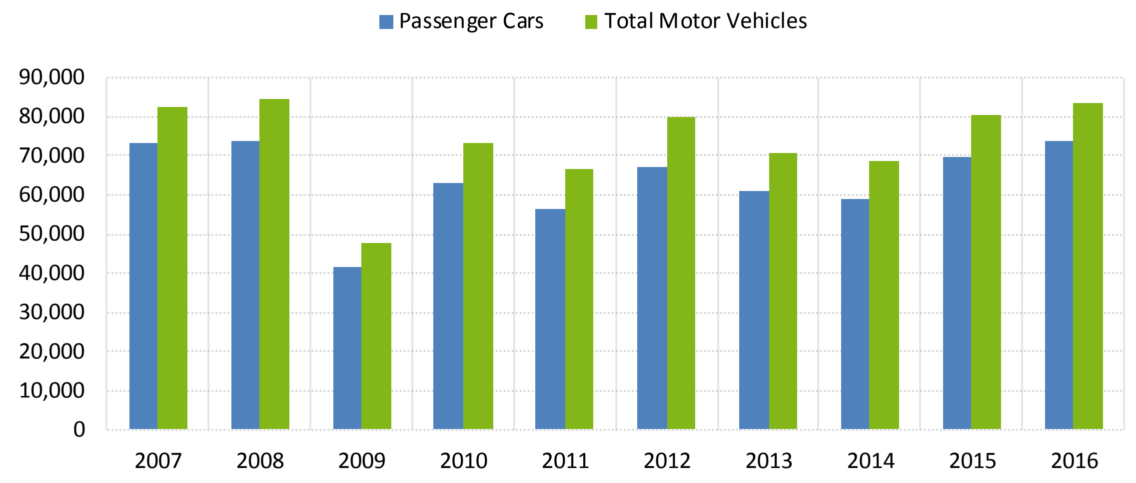
Figure 139
Japan: Net Production of Vehicles



Source: OICA, production and sales data.

Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

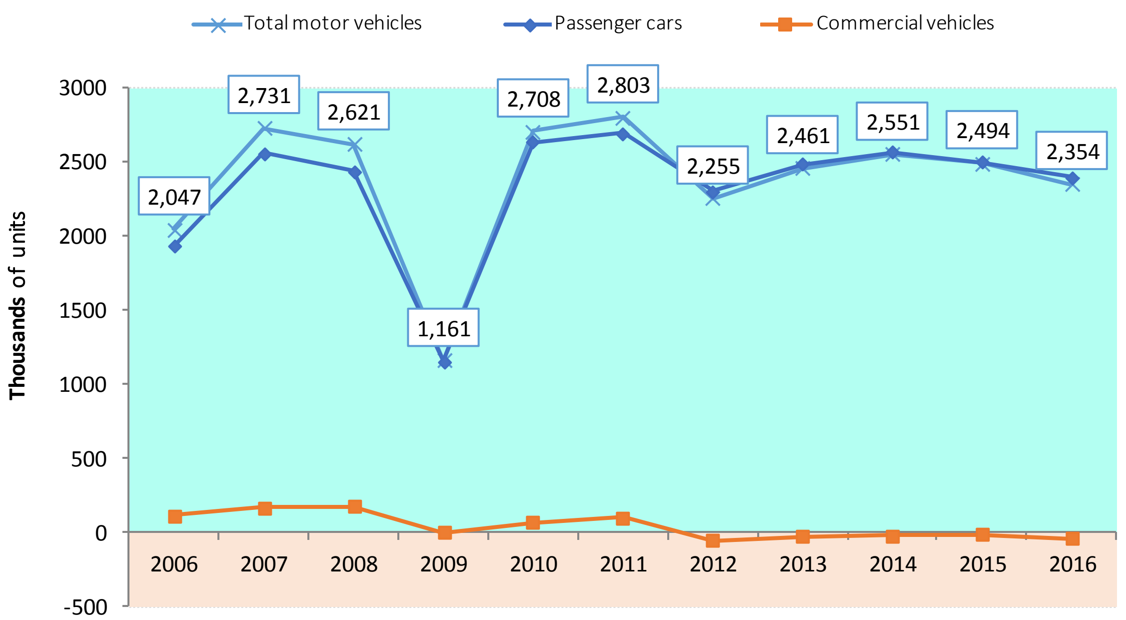
Figure 140
Japan: Net Exports of Vehicles (in € Million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

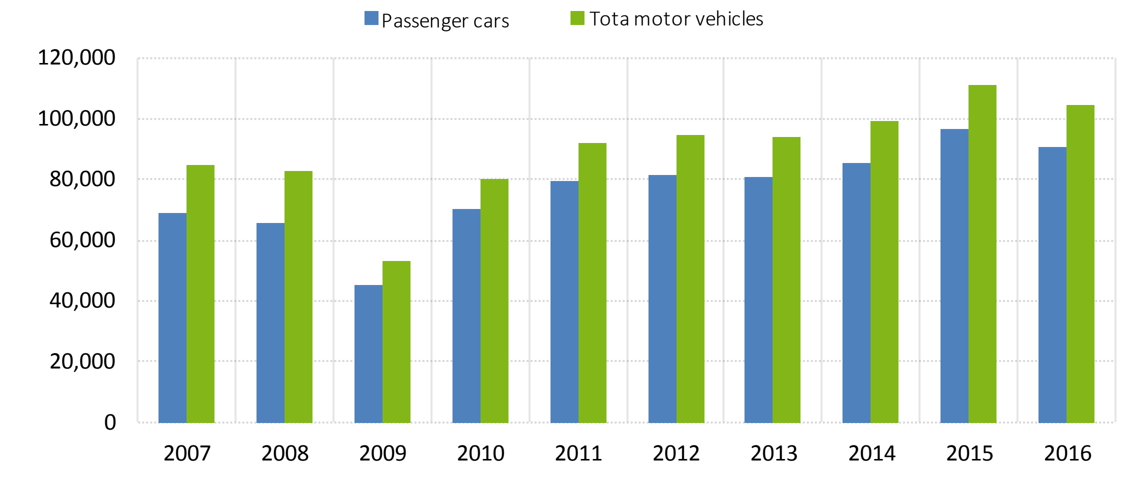
1.3.2.4. Germany

Figure 141
Germany: Net Production of Vehicles



Source: OICA, production and sales data.
Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

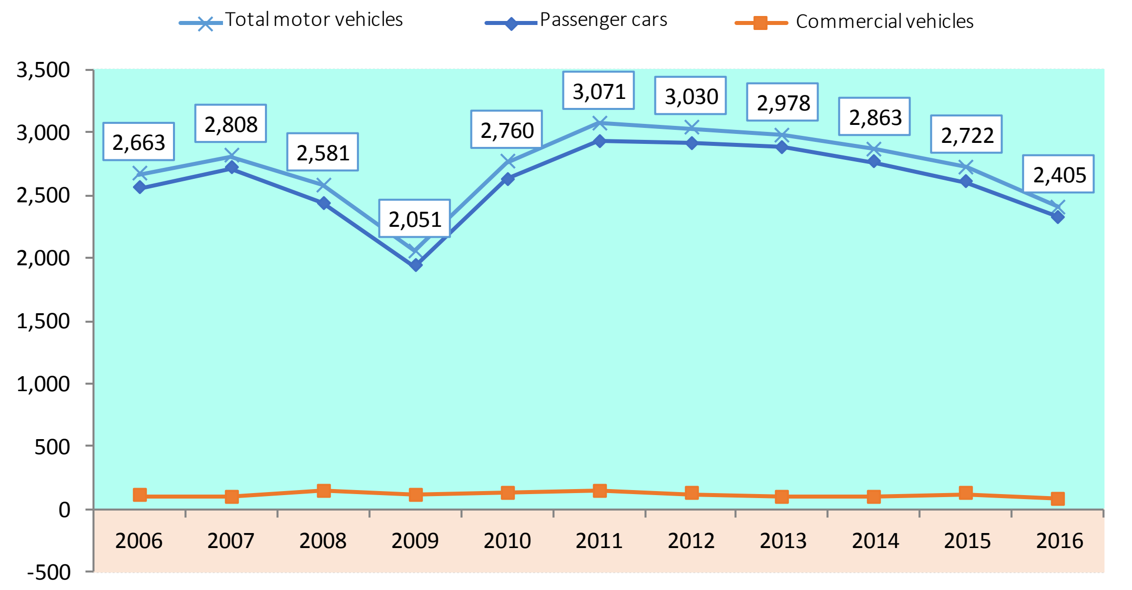
Figure 142
Germany: Net Exports of Vehicles (in € Million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

1.3.2.5. South Korea

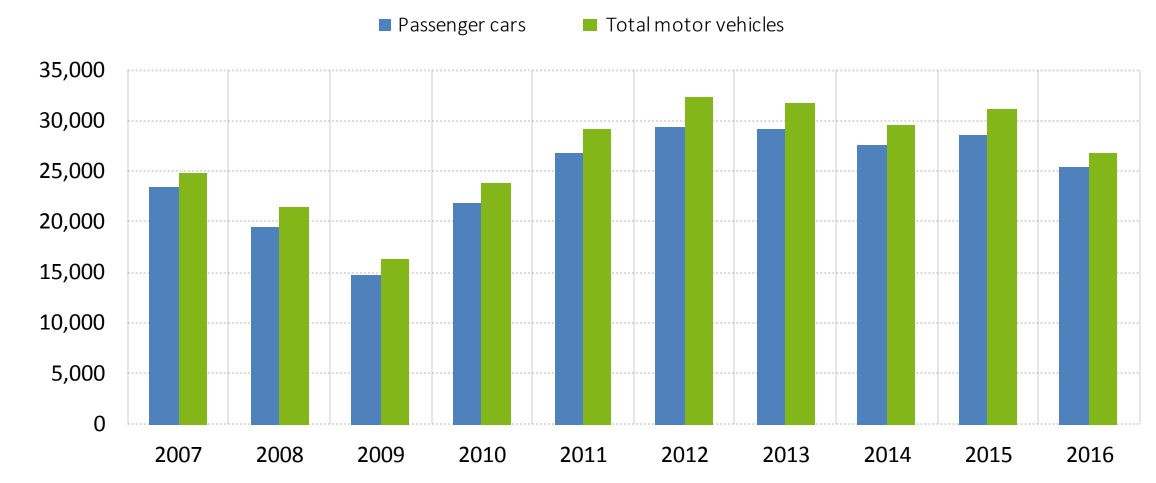
Figure 143
South Korea: Net Production of Vehicles (in 1,000 Units)



Source: OICA, production and sales data.

Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

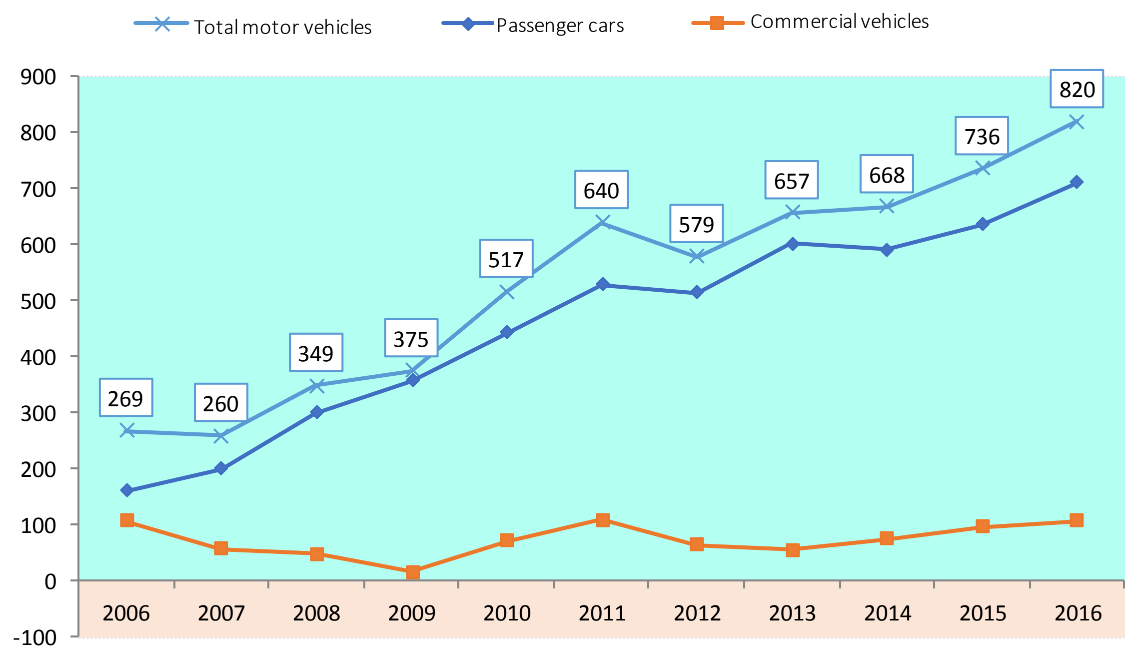
Figure 144
South Korea: Net Exports of Vehicles (in € Million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

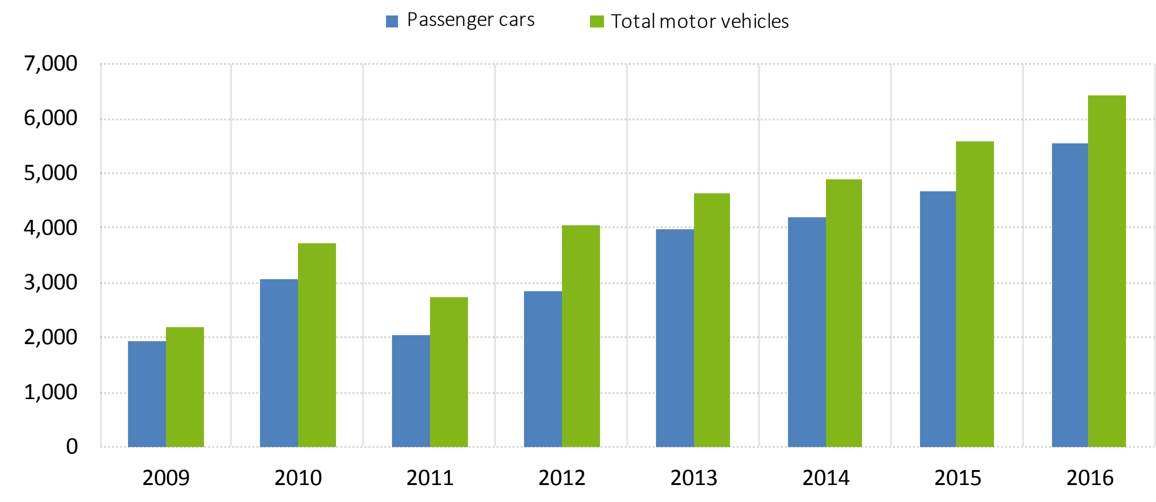
1.3.2.6. India

Figure 145
India: Net Production of Vehicles (in 1,000 Units)



Source: OICA, production and sales data.
Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

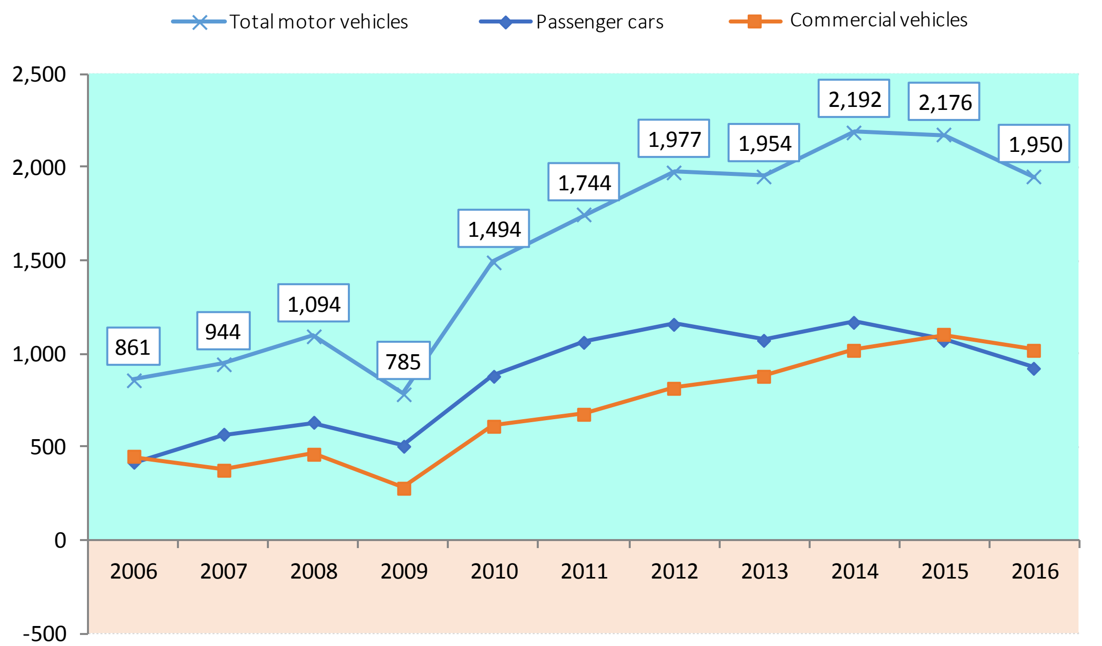
Figure 146
India: Net Exports of Vehicles (in € Million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

1.3.2.7. Mexico

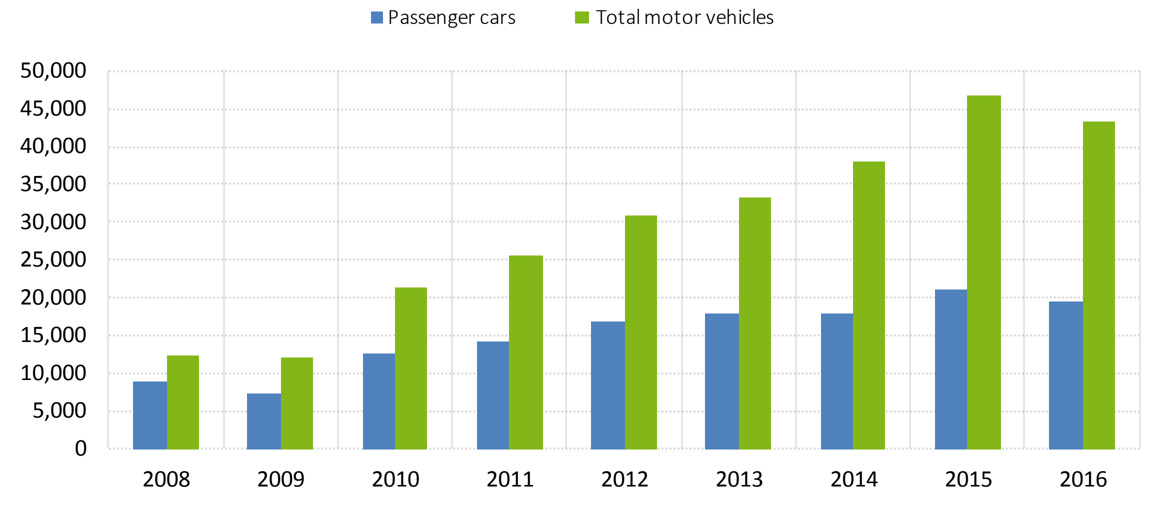
Figure 147
Mexico: Net Production of Vehicles (in 1,000 Units)



Source: OICA, production and sales data.

Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

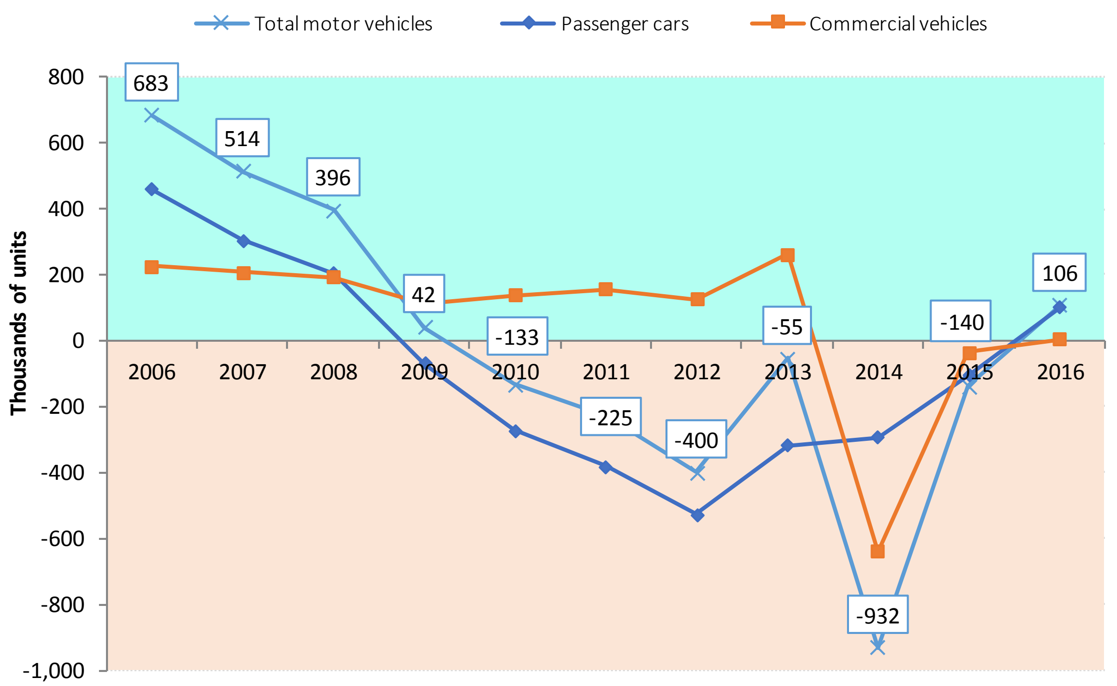
Figure 148
Mexico: Net Exports of Vehicles (in € Million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

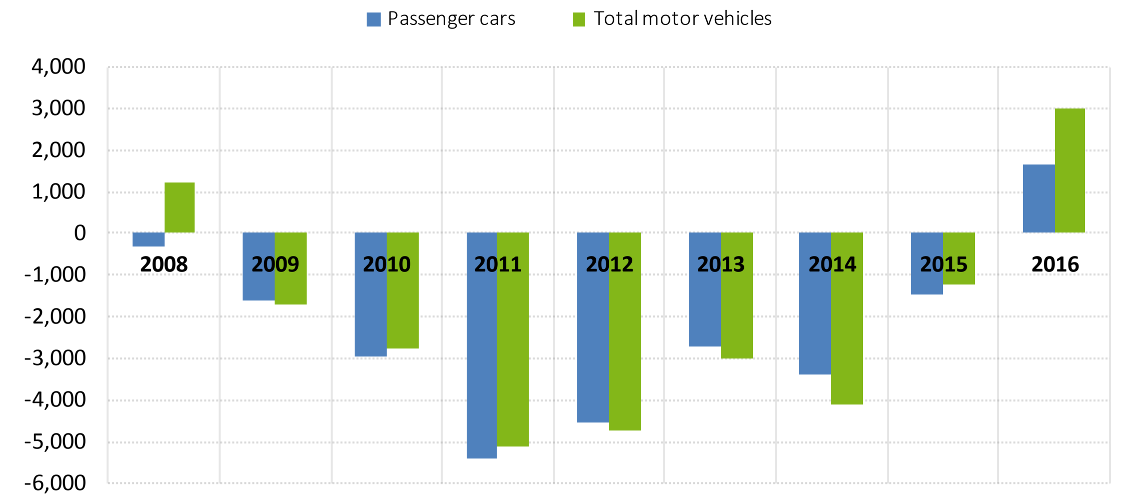
1.3.2.8. Brazil

Figure 149
Brazil: Net Production of Vehicles



Source: OICA, production and sales data.
Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

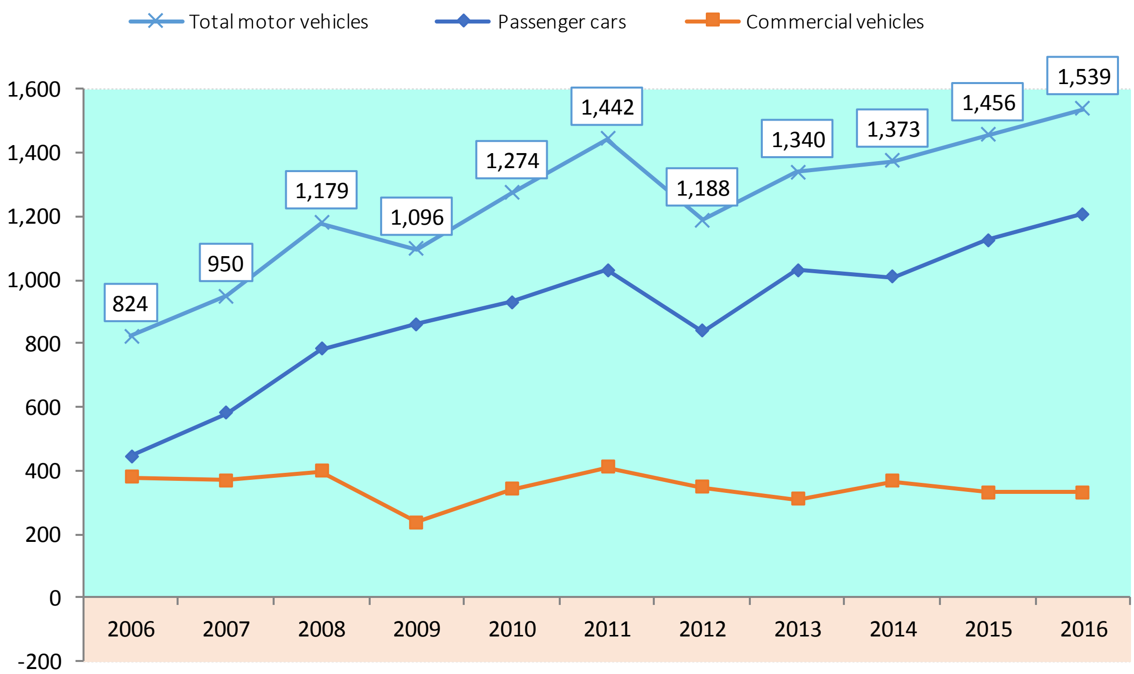
Figure 150
Brazil: Net Exports of Vehicles (in € Million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

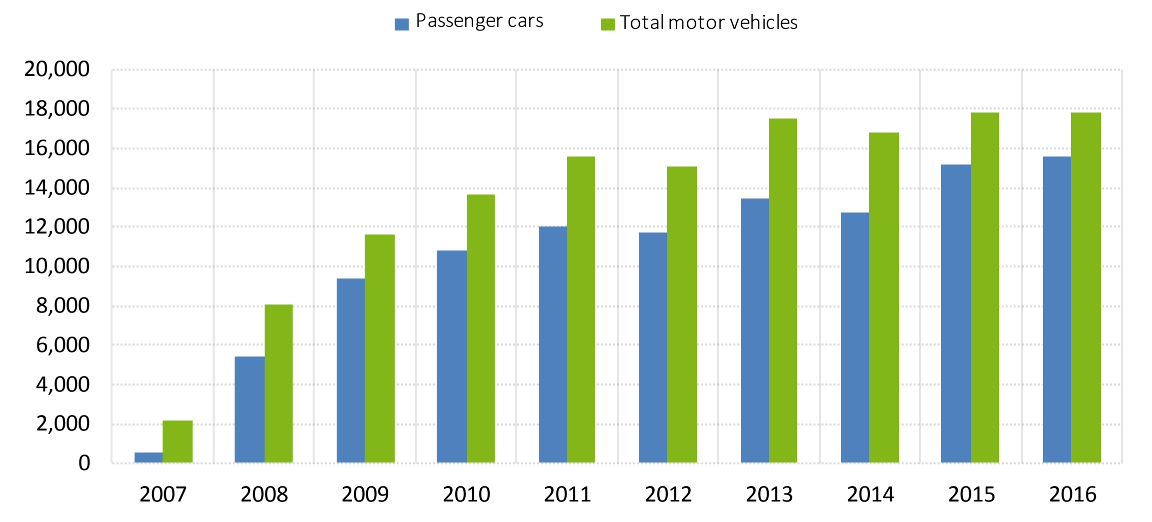
1.3.2.9. Spain

Figure 151
Spain: Net Production of Vehicles (in 1,000 Units)



Source: OICA, production and sales data.
Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

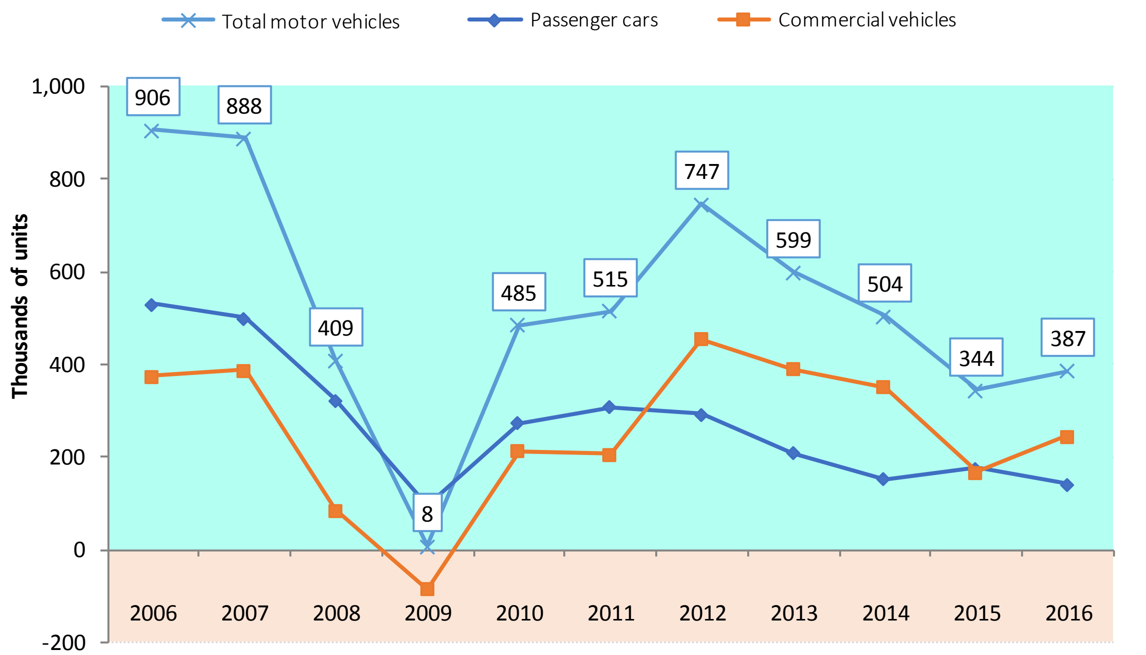
Figure 152
Spain: Net Exports of Vehicles (in € Million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

1.3.2.10. Canada

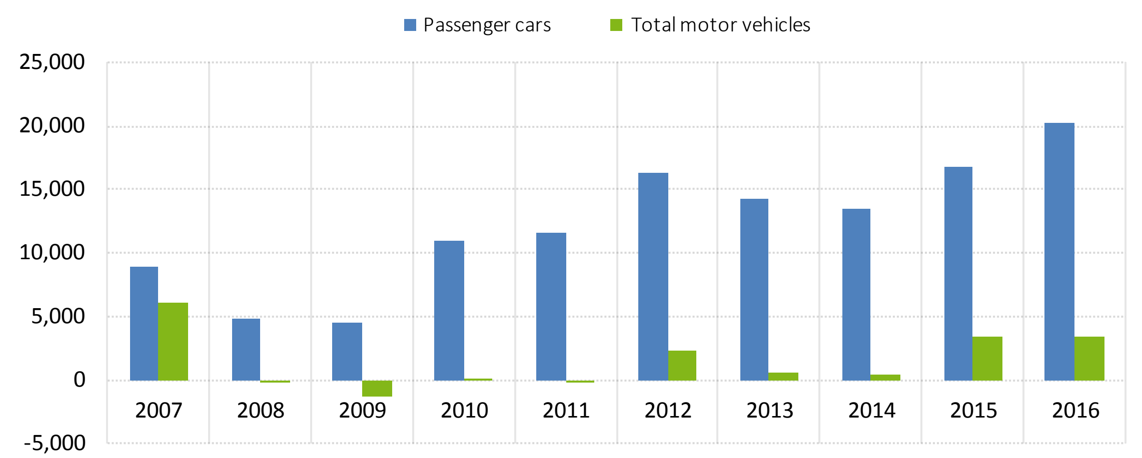
Figure 153
Canada: Net Production of Vehicles



Source: OICA, production and sales data.

Note: Commercial vehicles include light commercial vehicles (excluding cars), heavy-duty vehicles, and heavy buses.

Figure 154
Canada: Net Exports of Vehicles (in € Million)



Sources: UN Comtrade, trade data; ECB, exchange rate data.

1.4. Vehicles in Use

1.4.1. Motorization Rate

Economic growth is strongly associated with an increase in demand for transportation, particularly in the number of road vehicles.

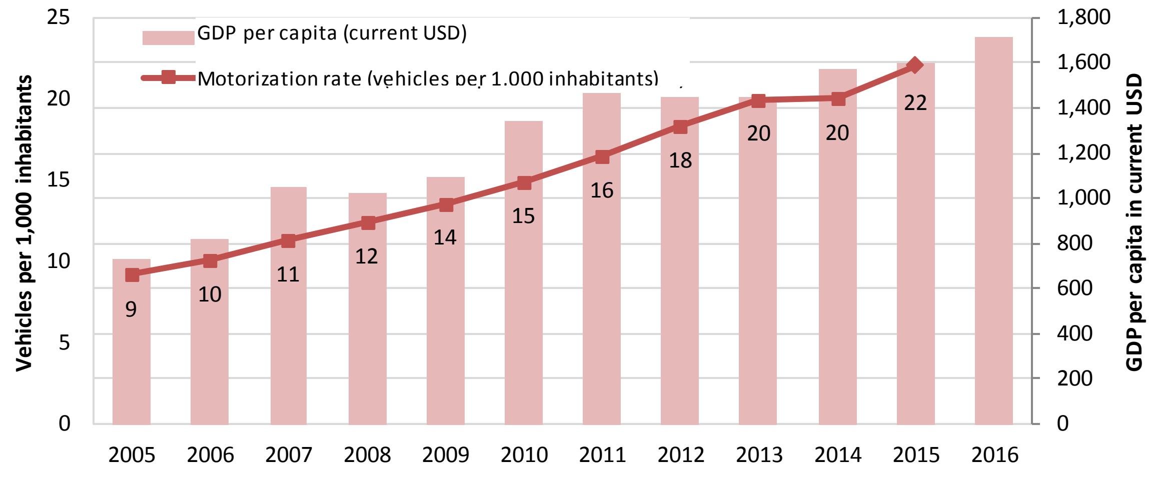
Although there is still no consensus regarding which function is best suited to estimating that relation, studies conducted so far agree that the relation between growth in vehicle ownership and per capita income is nonlinear.

According to the literature on the topic, vehicle ownership grows relatively slowly at the lowest levels of per capita income, then about twice as fast as income at middle-income levels and, finally, about as fast as income at higher income levels, before reaching saturation at the highest levels of income (Dargay, Gately and Sommer 2007).

The functions to describe this dynamic are S-shaped functions, such as the Gompertz function, the logistic, the logarithmic logistic, and the cumulative normal (Dargay, Gately and Sommer 2007).

This section shows data on vehicle ownership (total number of vehicles per 1,000 habitants or the motorization rate) and per capita income (GDP per capita in US dollars at purchasing-power parity or PPP) for the top 10 manufacturing countries. A logarithmic function is used to estimate the abovementioned relationship. The logarithmic function works well in this case, despite it not having an S-shaped curve. This is because there are no low-income countries in the sample. The Gompertz and logistic functions are particularly good for capturing flat growth in the left part of the curve (low-income levels). In this report, however, a logarithmic function fits well because the focus here is on the right, concave part of the S-shaped curve (middle to high-income levels).

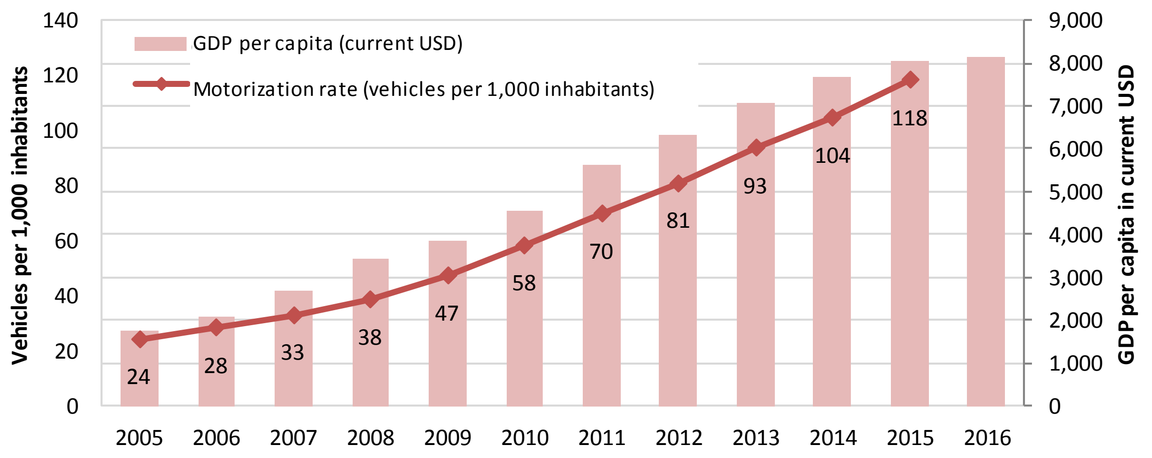
Figure 155
Motorization Rate in India



Source: OICA, Vehicles in Use; IMF, GDP PPP data; World Bank, Population Statistics.

In the case of India (a middle-income country), GDP per capita (current US dollars) grew at an average annual rate of 9% between 2005 and 2014, while growth in the number of vehicles per 1,000 habitants was slightly higher, with an average annual rate of 10%.

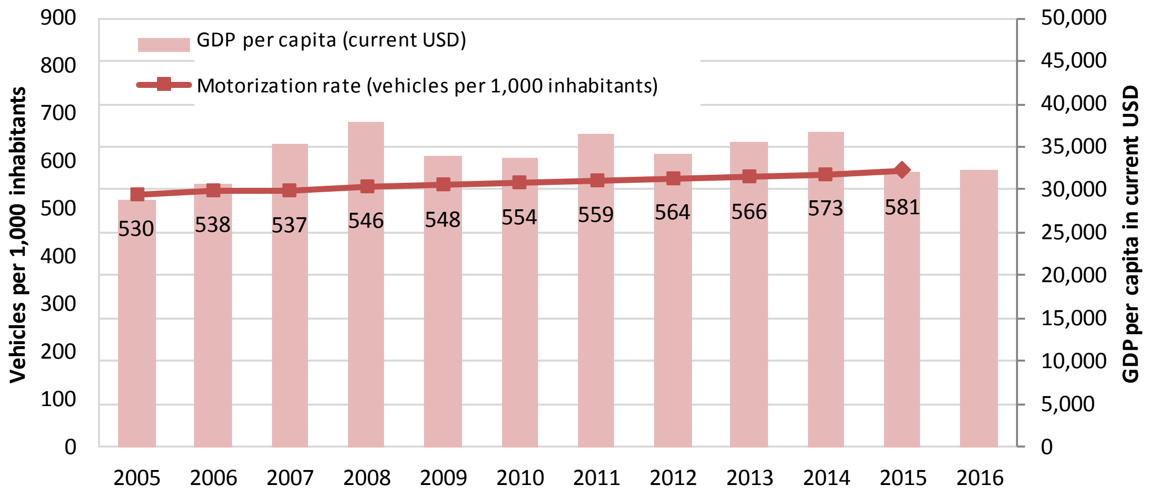
Figure 156
Motorization Rate in China



Source: OICA, Vehicles in Use; IMF, GDP PPP data; World Bank, Population Statistics.

In the case of China (an upper-middle-income country) is similar to that of India: GDP per capita (current US dollars) in China increased by an average annual rate of 18% between 2005 and 2014, with vehicle ownership growing at the same average annual rate of 18%.

Figure 157
Motorization Rate in the EU-28



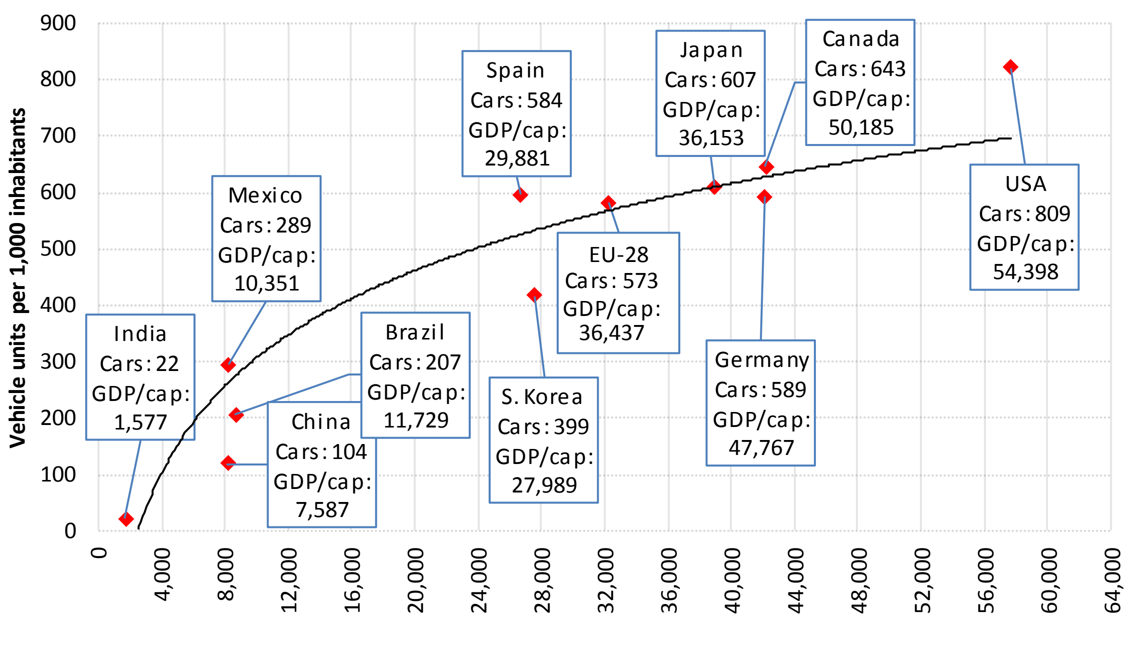
Source: OICA, Vehicles in Use; IMF, GDP PPP data; World Bank, Population Statistics.

The EU-28 data describes the high-income country dynamics: while GDP per capita (current US dollars) rose 3% per year on average between 2005 and 2014, vehicle ownership grew even more slowly, posting 1% average annual growth in the same period.

The following graph shows that middle-income countries are associated with the steeper part of the logarithmic curve (on the left), while high-income countries are concentrated along the low gradient part of the curve (on the right).

Figure 158

Motorization Rate and GDP per Capita in Top 10 Manufacturing Countries in 2015



Sources: OICA, Vehicles in Use; IMF, GDP PPP data; World Bank, Population Statistics.
Note: Logarithmic trend line. R-squared: 0.8885.

Table 1

Motorization Rate (Number of Vehicles per 1,000 Inhabitants)

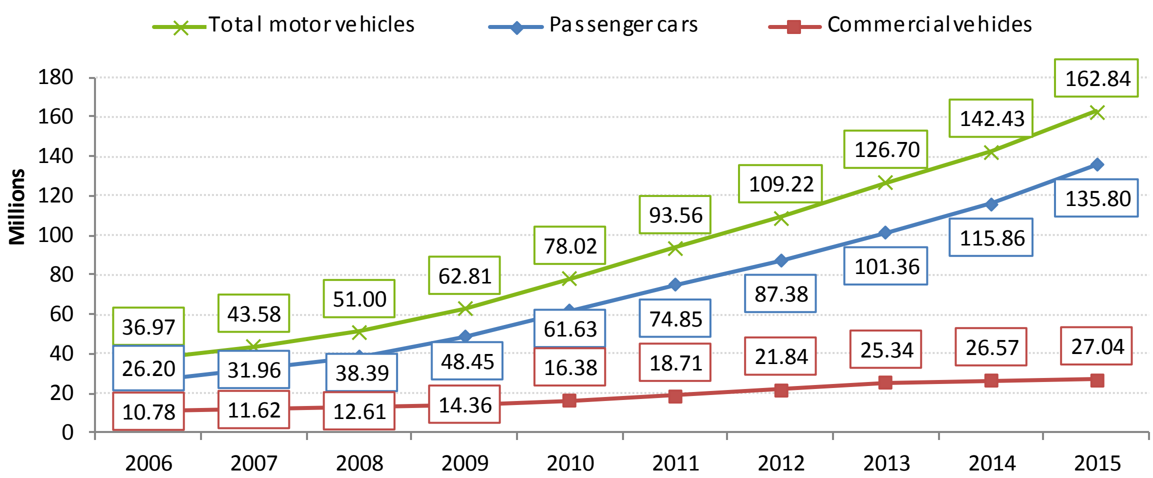
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EU-28	543	552	551	560	562	567	574	578	581	585	594
China	24	28	33	38	47	58	70	81	93	107	119
USA	804	820	826	821	812	802	799	801	799	810	823
Japan	592	593	592	590	588	588	591	596	601	606	609
Germany	597	604	535	538	545	553	573	579	583	588	593
S. Korea	320	328	337	342	351	362	369	376	385	396	411
India	9	10	11	12	13	15	16	18	19	20	22
Mexico	199	220	231	248	257	260	268	276	285	288	297
Brazil	123	127	134	143	152	163	175	186	196	205	208
Spain	576	591	601	601	591	591	590	588	582	583	591
Canada	585	601	610	617	618	624	629	625	635	643	648

Sources: OICA, Vehicles in Use; IMF, GDP PPP data; World Bank, Population Statistics.

1.4.2. Top Manufacturing Countries

1.4.2.1. China

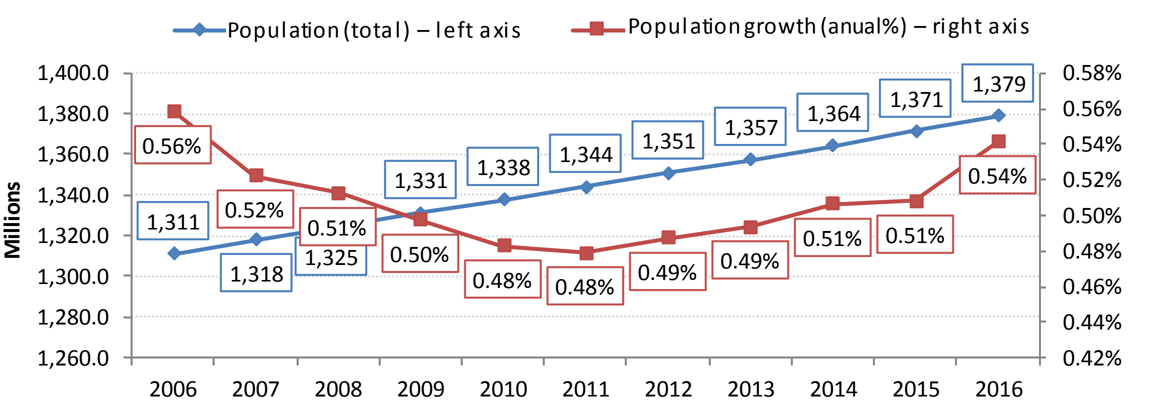
Figure 159
China: Vehicles in Use



Source: OICA, Vehicles in Use.

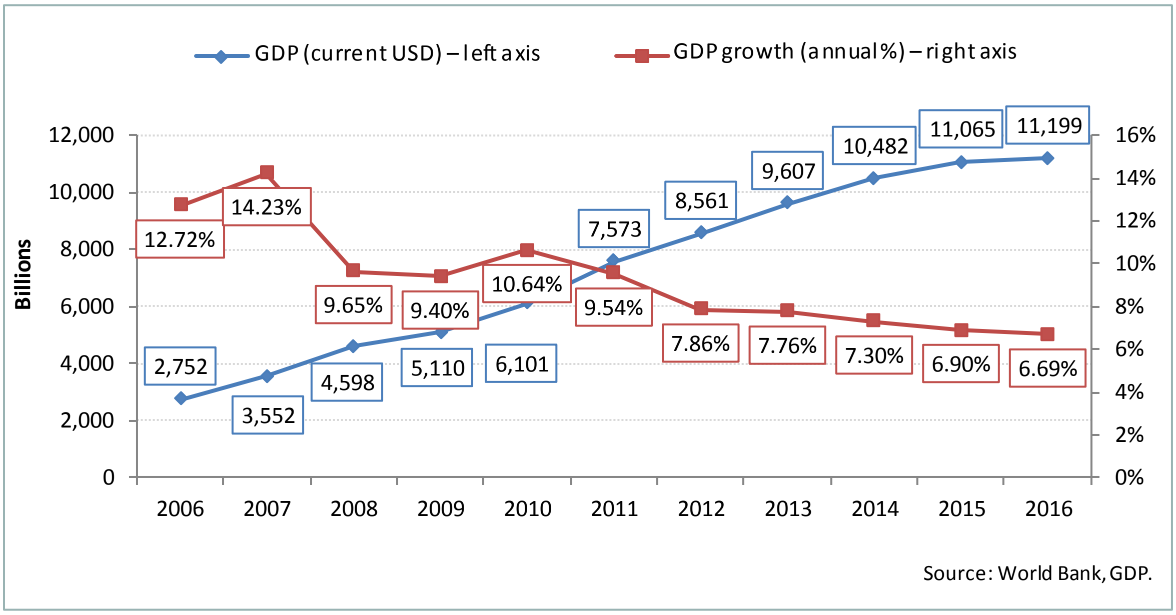
Note: Data for 2010 to 2012 estimated by OICA.

Figure 160
China: Population Statistics



Source: World Bank, Population Statistics.

Figure 161
China: GDP



1.4.2.2. USA

Figure 162
United States: Vehicles in Use

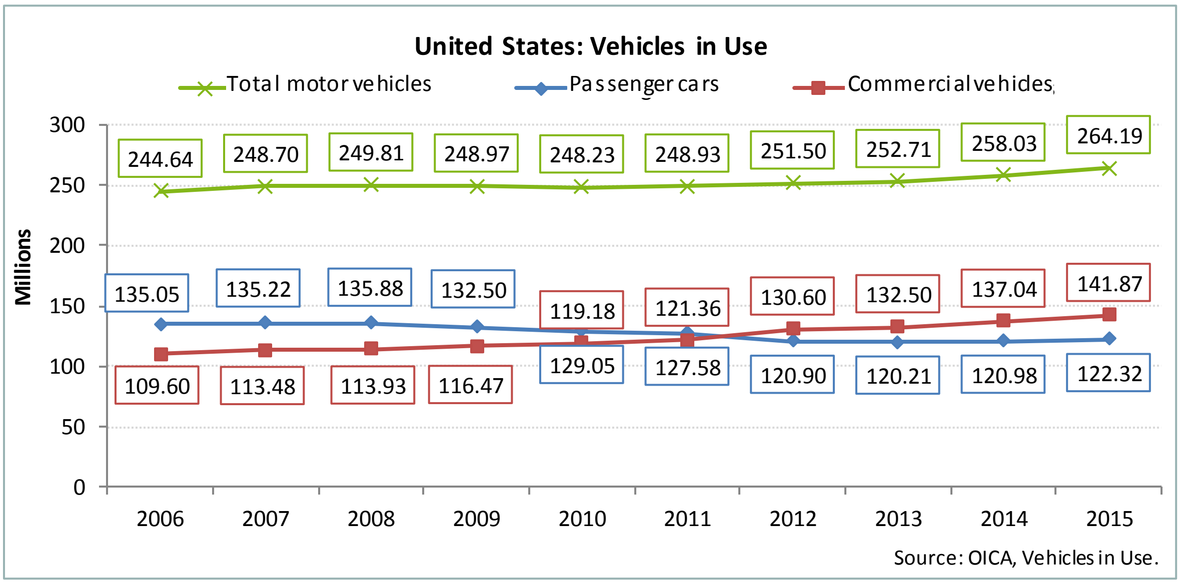


Figure 163
United States: Population Statistics

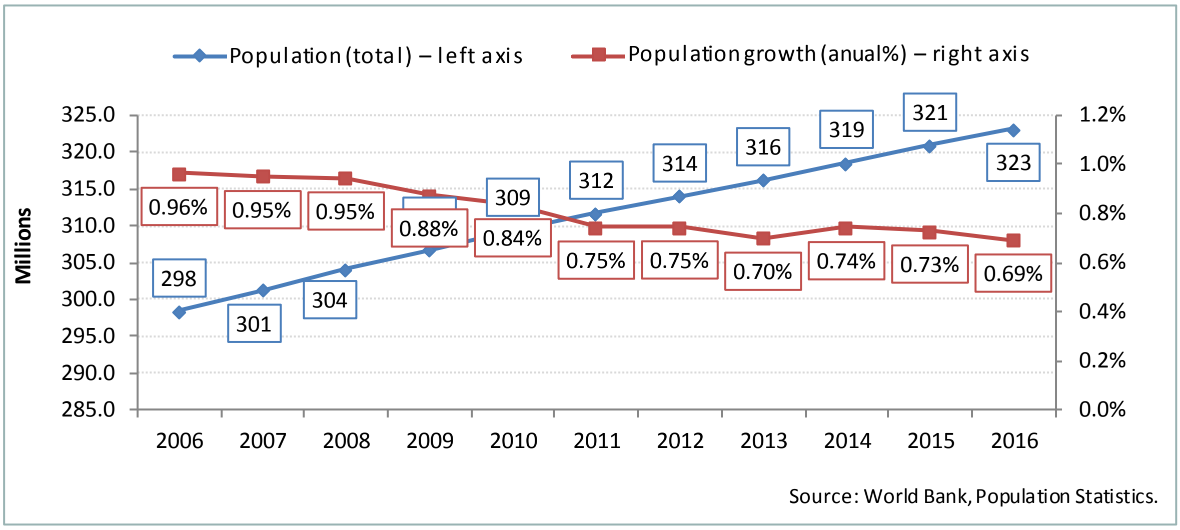
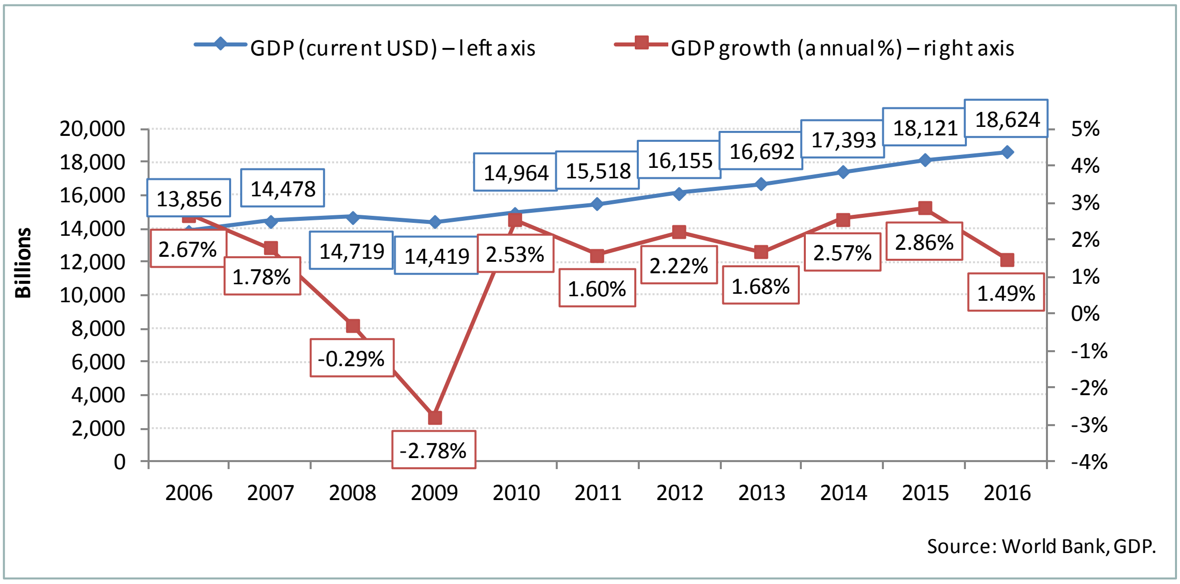
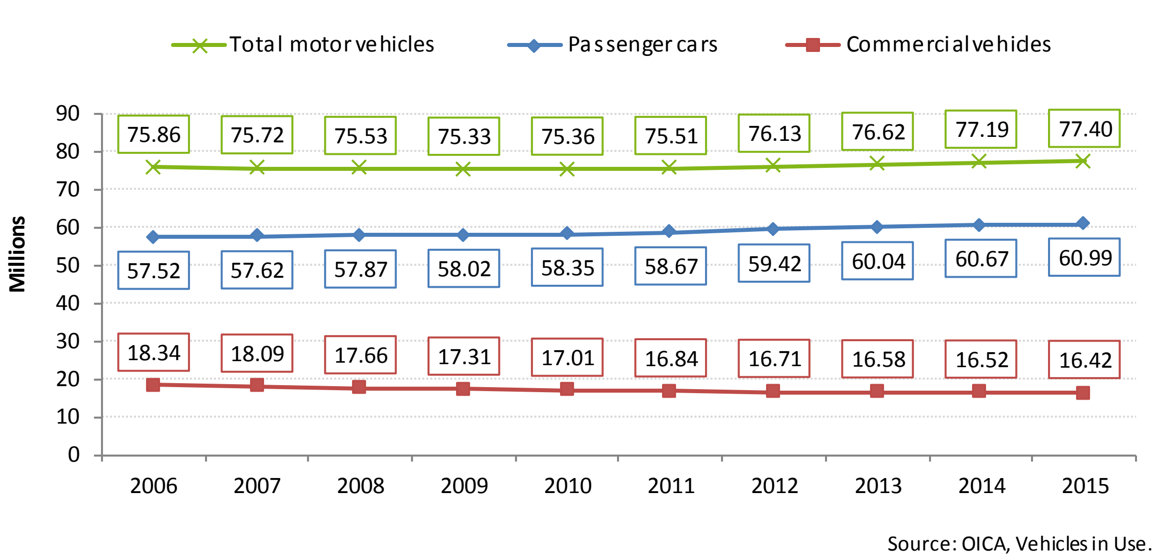


Figure 164
United States: GDP



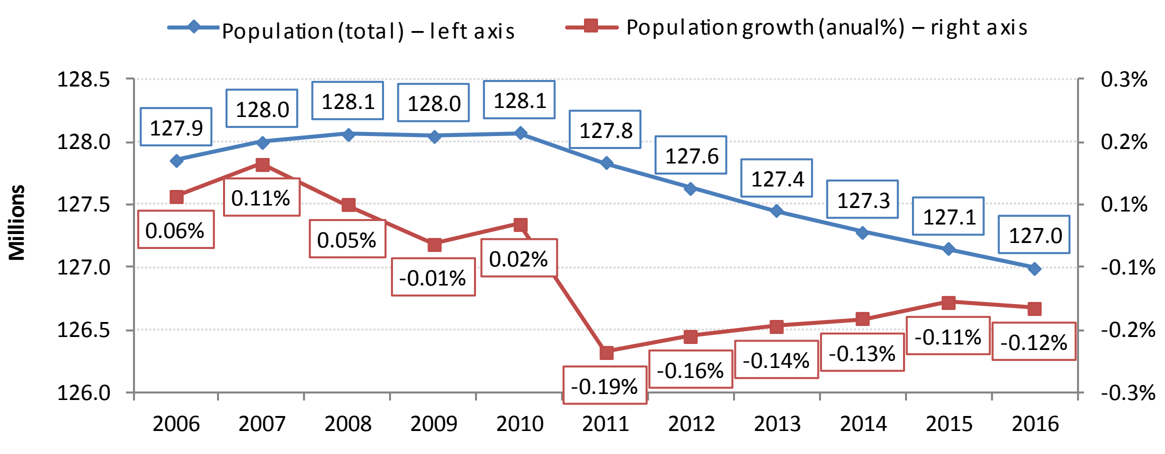
1.4.2.3. Japan

Figure 165
Japan: Vehicles in Use



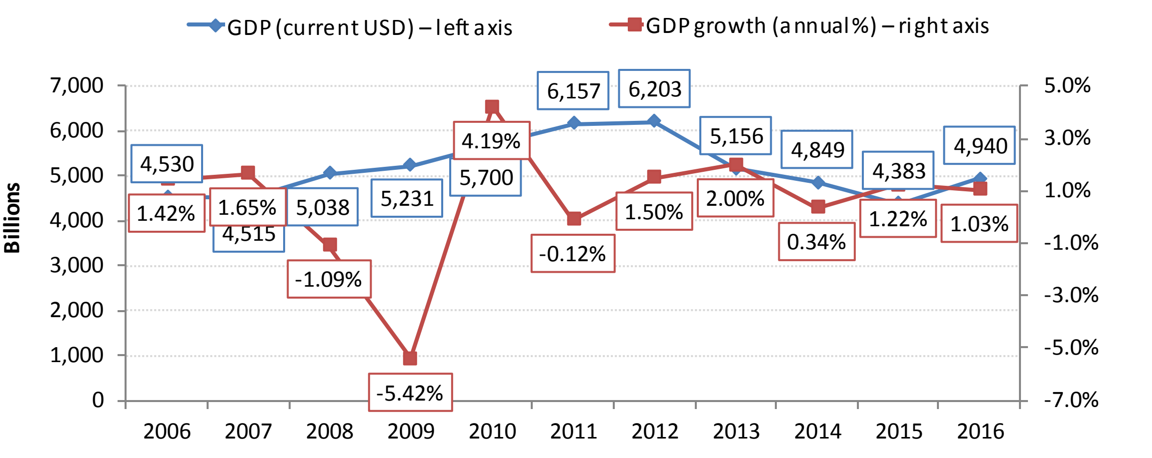
Source: OICA, Vehicles in Use.

Figure 166
Japan: Population Statistics



Source: World Bank, Population Statistics.

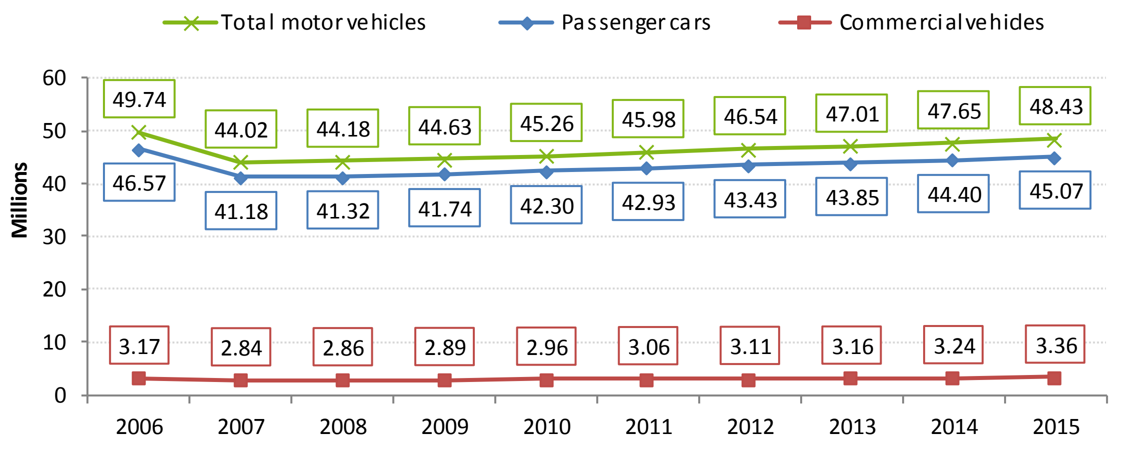
Figure 167
Japan: GDP



Source: World Bank, GDP.

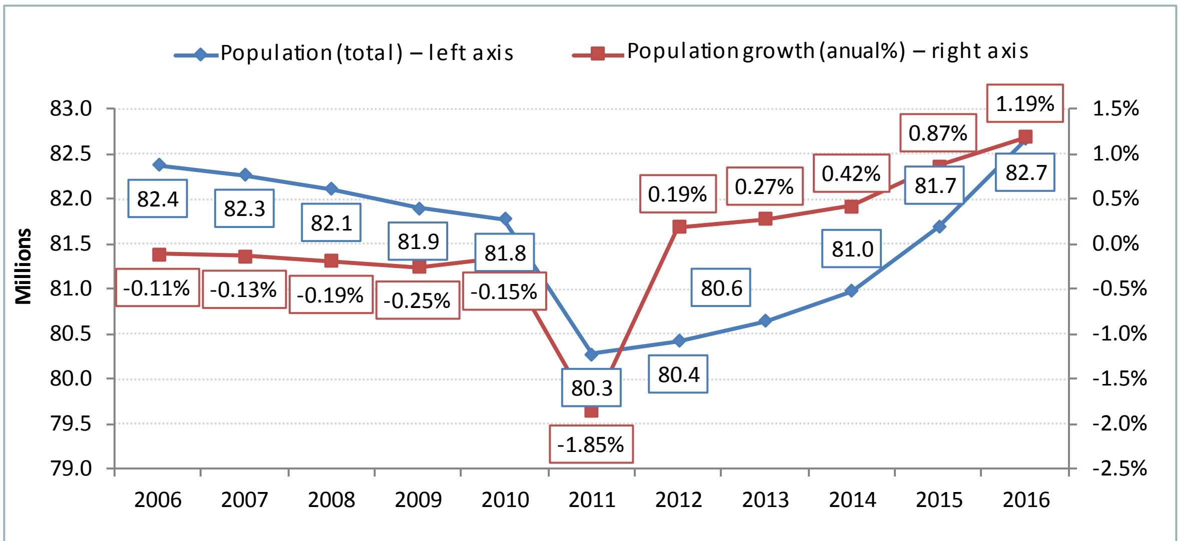
1.4.2.4. Germany

Figure 168
Germany: Vehicles in Use



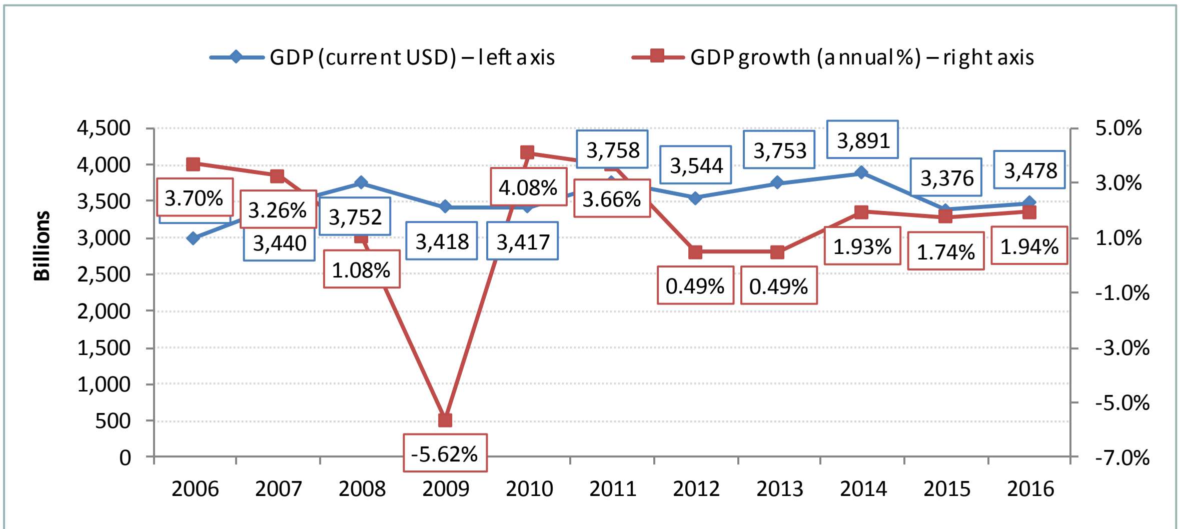
Source: OICA, Vehicles in Use.

Figure 169
Germany: Population Statistics



Source: World Bank, Population Statistics.

Figure 170
Germany: GDP



Source: World Bank, GDP.

1.4.2.5. South Korea

Figure 171
South Korea: Vehicles in Use

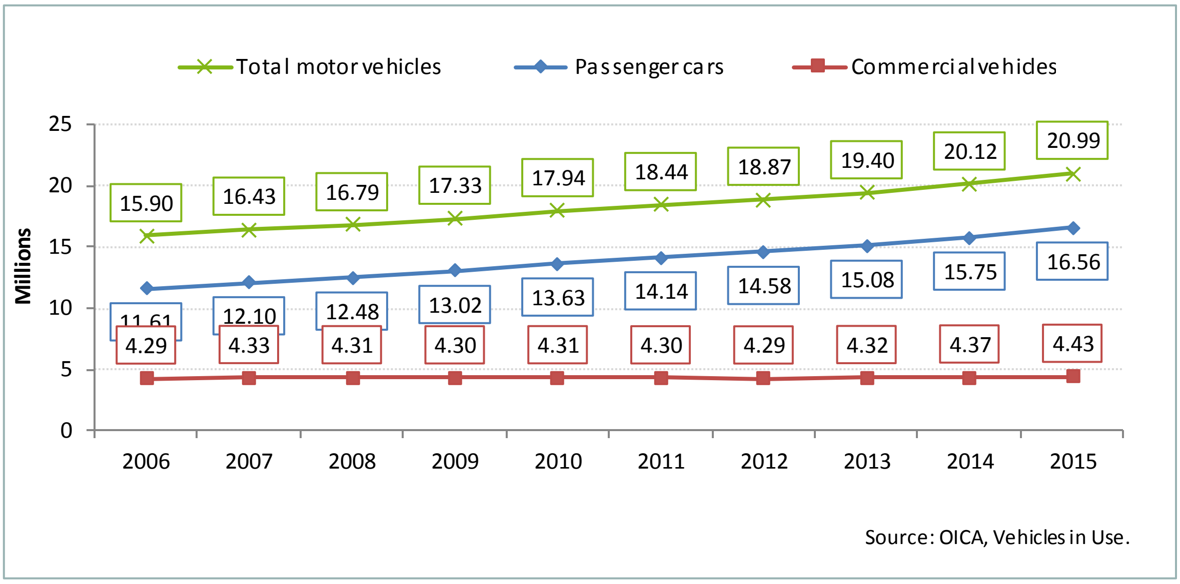


Figure 172
South Korea: Population Statistics

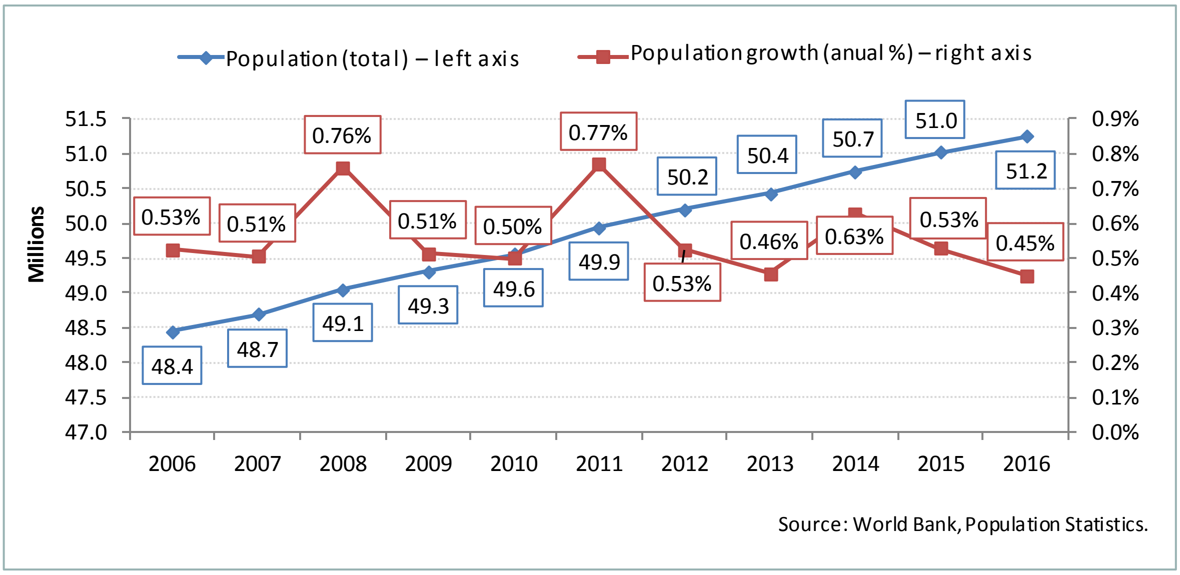
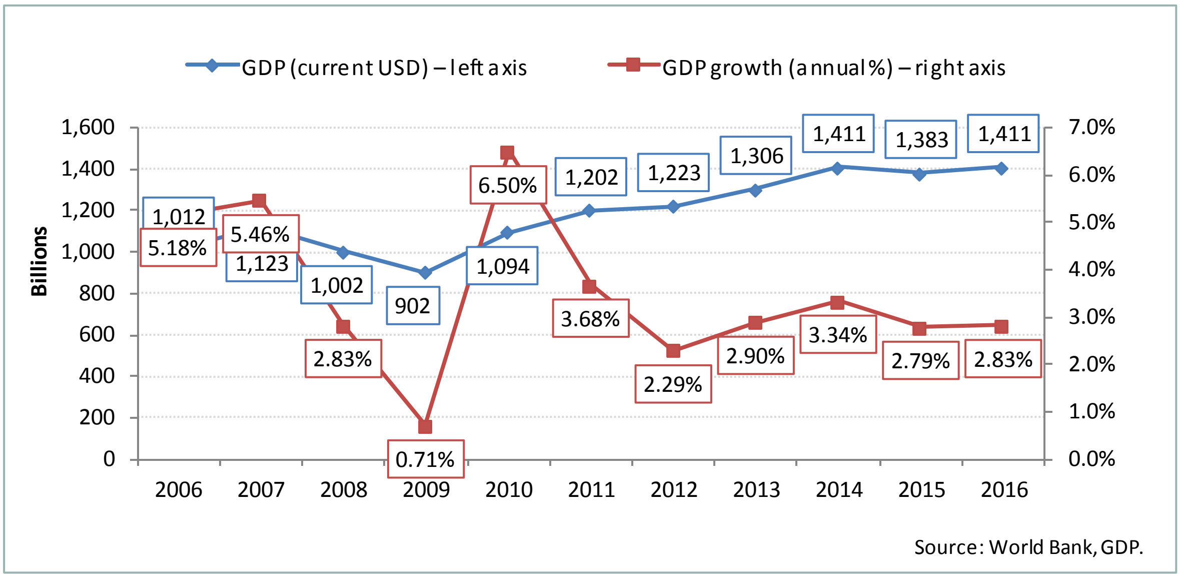


Figure 173
South Korea: GDP



1.4.2.6. India

Figure 174
India: Vehicles in Use

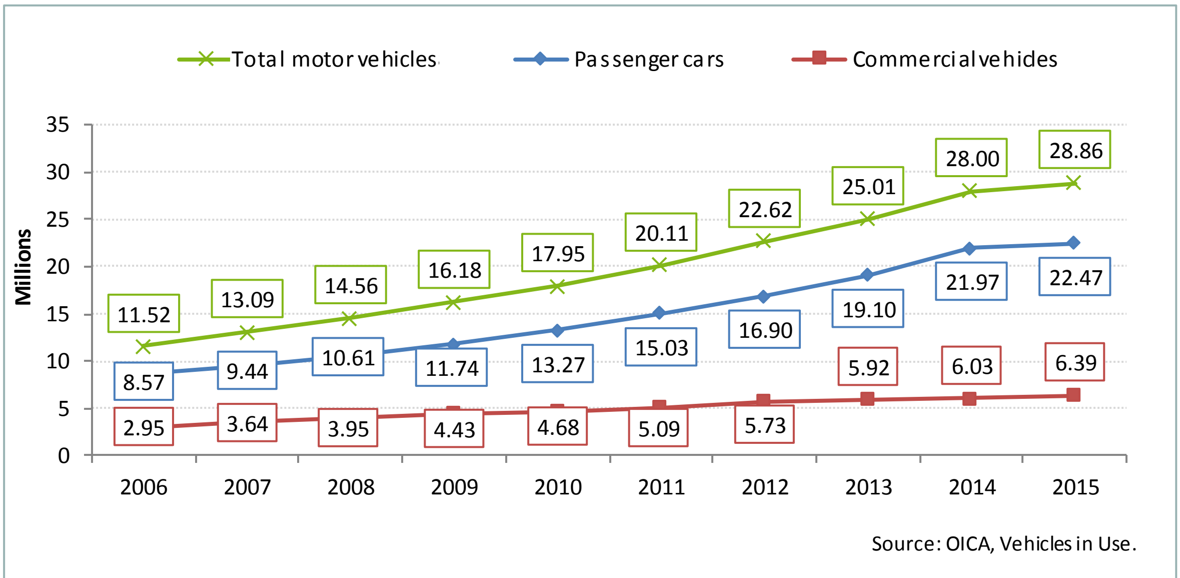
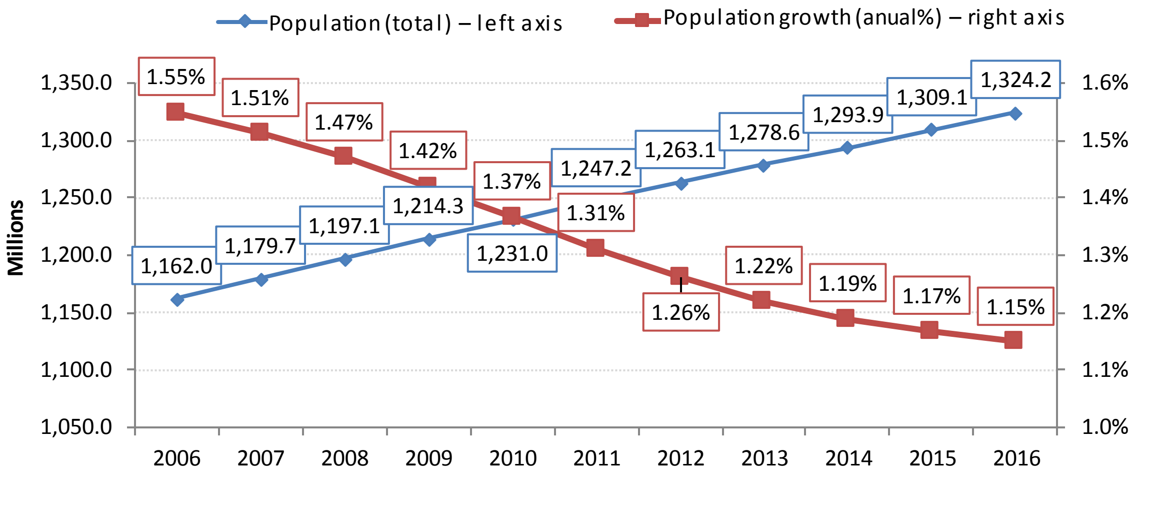
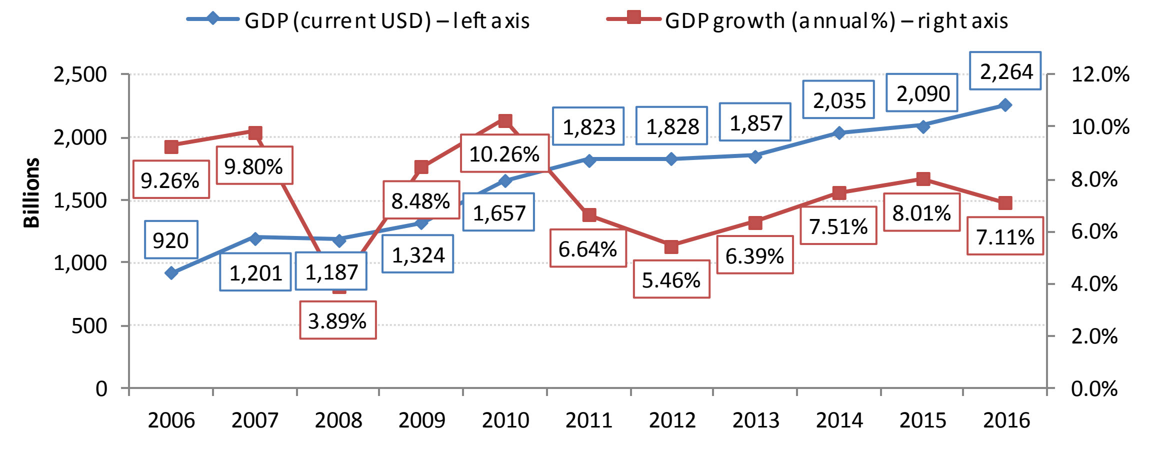


Figure 175
India: Population Statistics



Source: World Bank, Population Statistics.

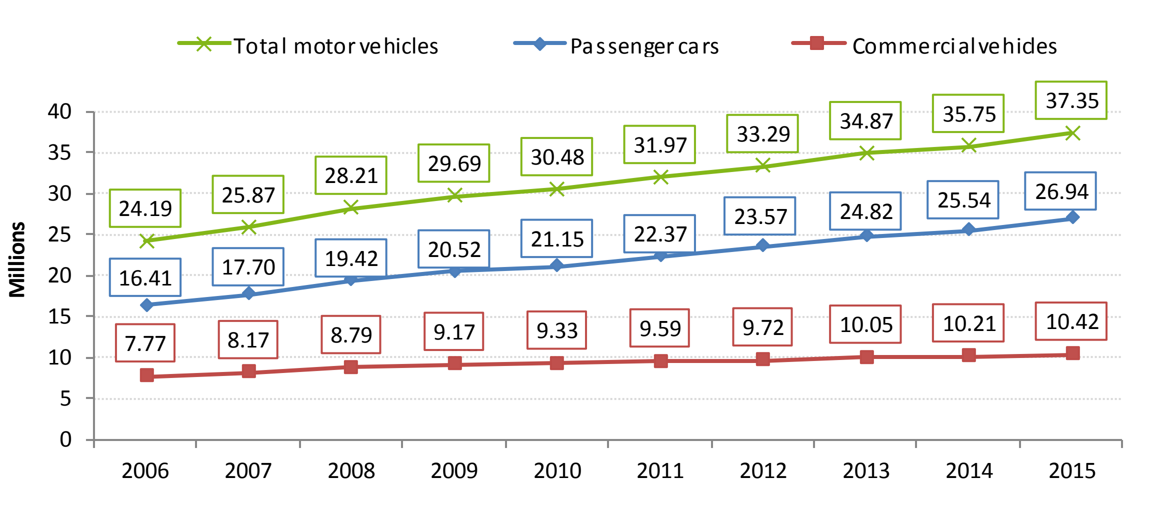
Figure 176
India: GDP



Source: World Bank, GDP.

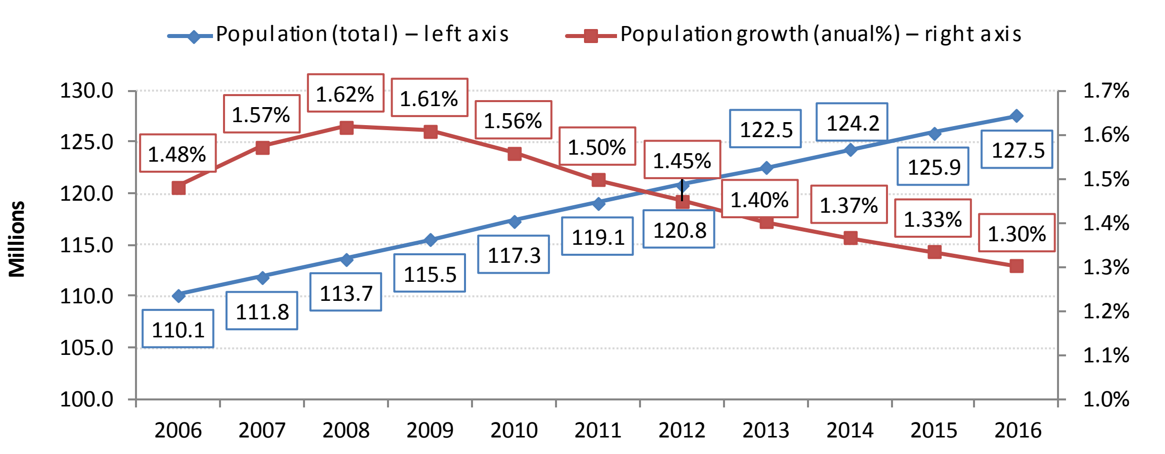
1.4.2.7. Mexico

Figure 177
Mexico: Vehicles in Use



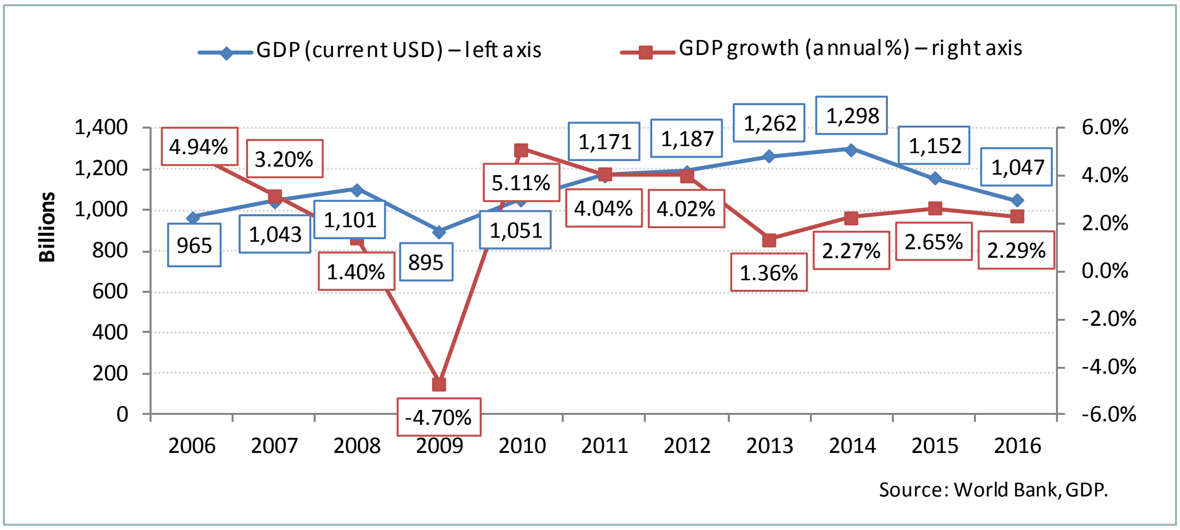
Source: OICA, Vehicles in Use.

Figure 178
Mexico: Population Statistics



Source: World Bank, Population Statistics.

Figure 179
Mexico: GDP



1.4.2.8. Brazil

Figure 180
Brazil: Vehicles in Use

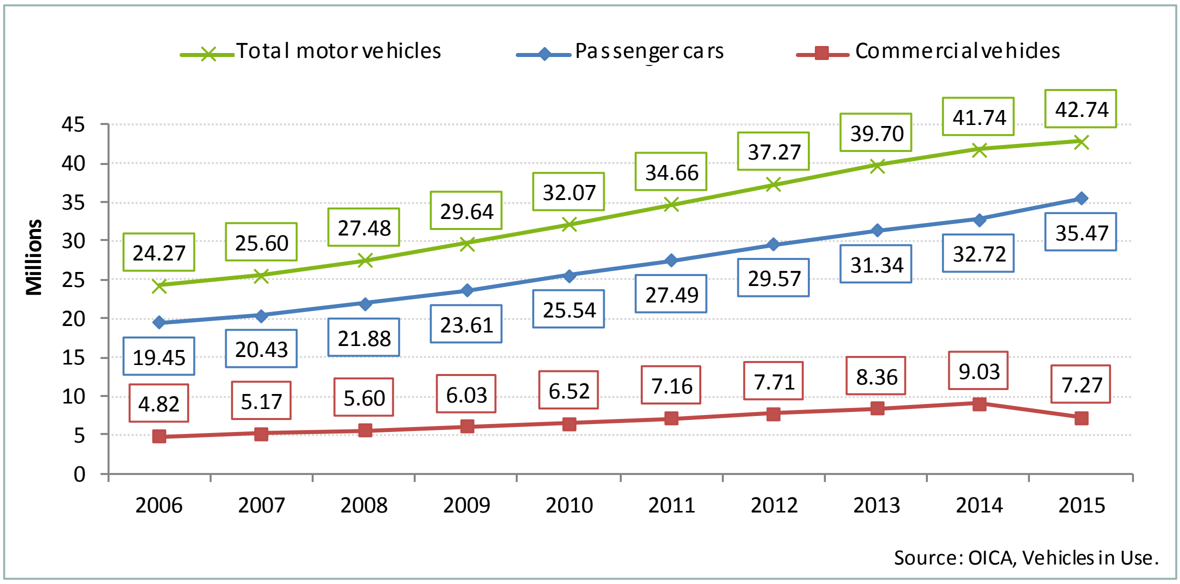


Figure 181
Brazil: Population Statistics

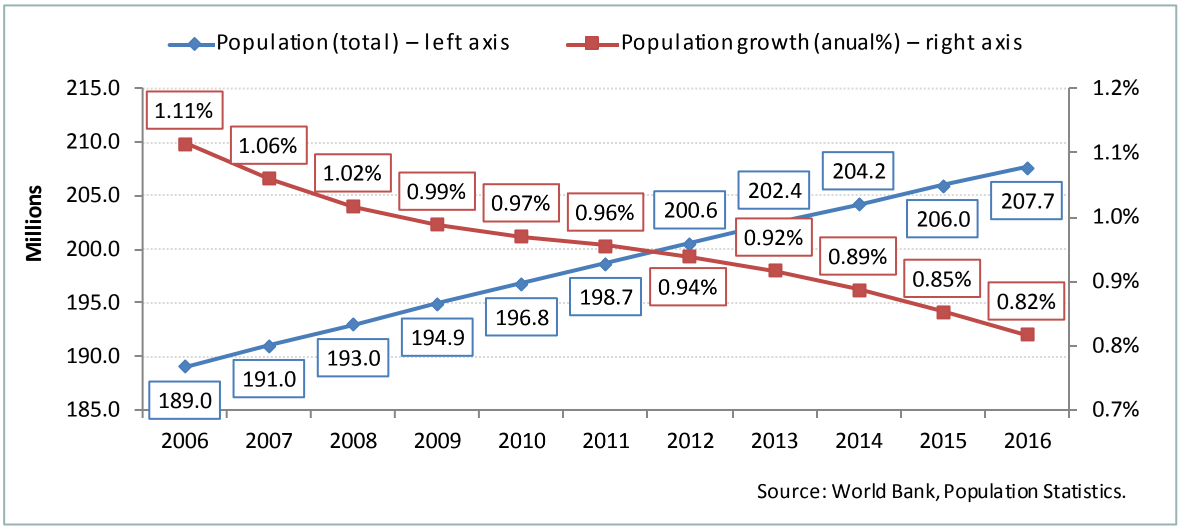
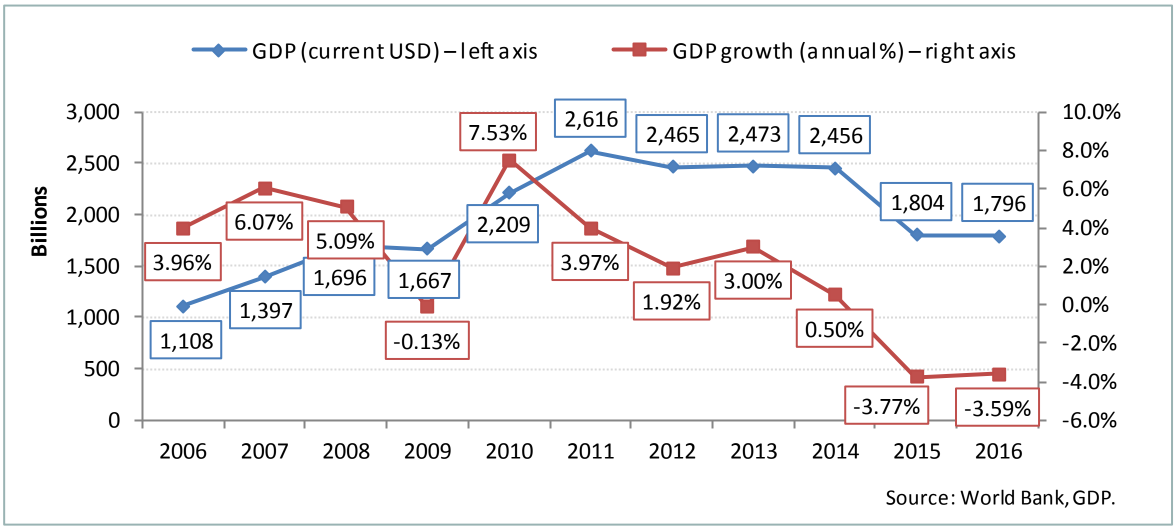


Figure 182
Brazil: GDP



1.4.2.9. Spain

Figure 183
Spain: Vehicles in Use

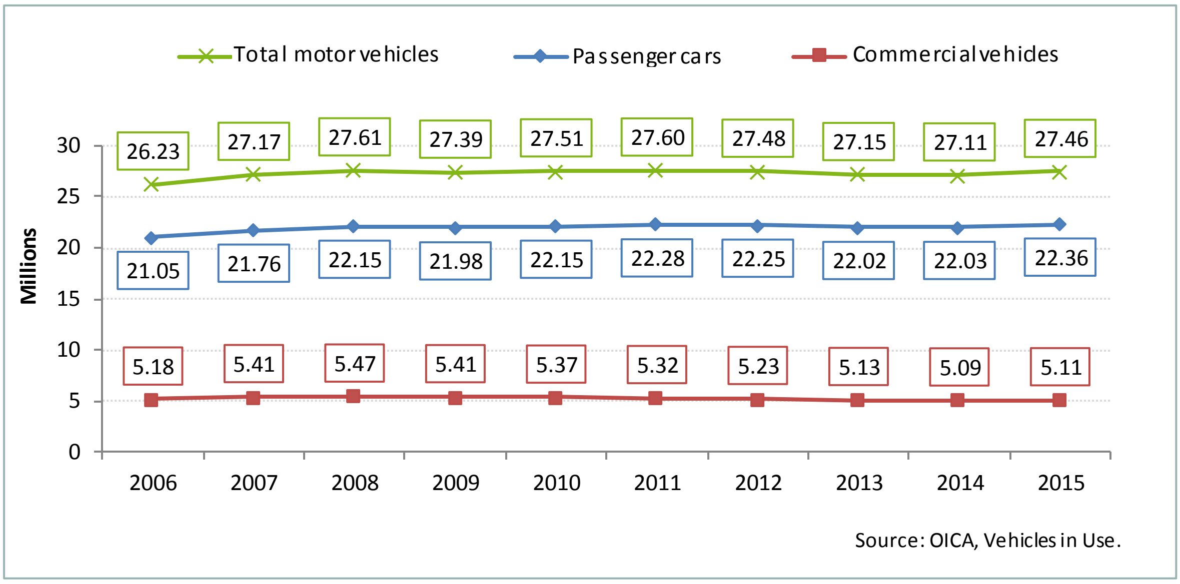


Figure 184
Spain: Population Statistics

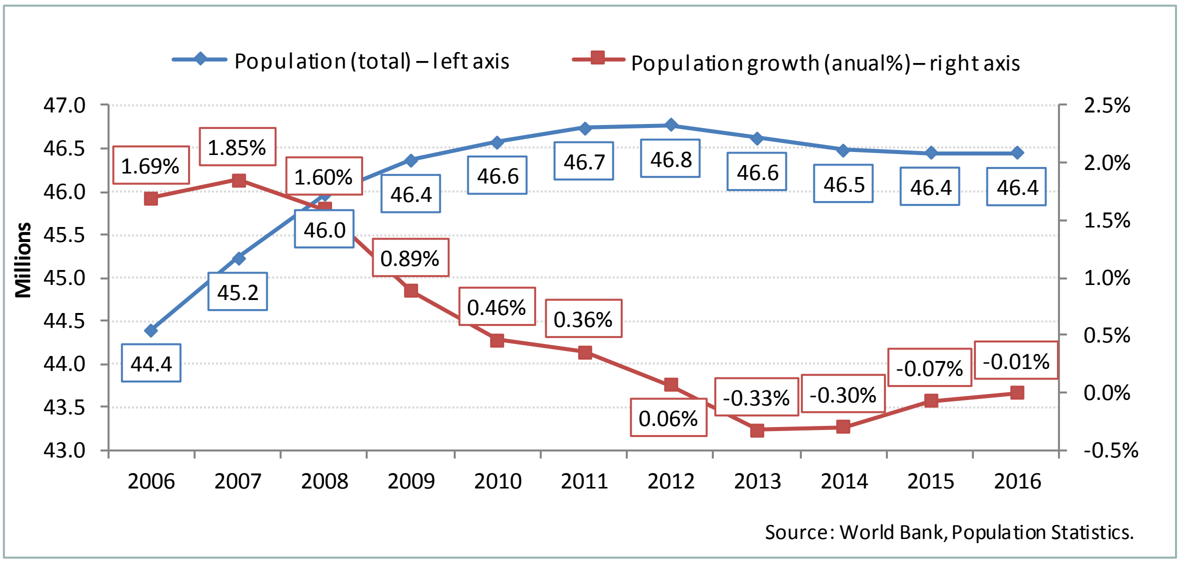
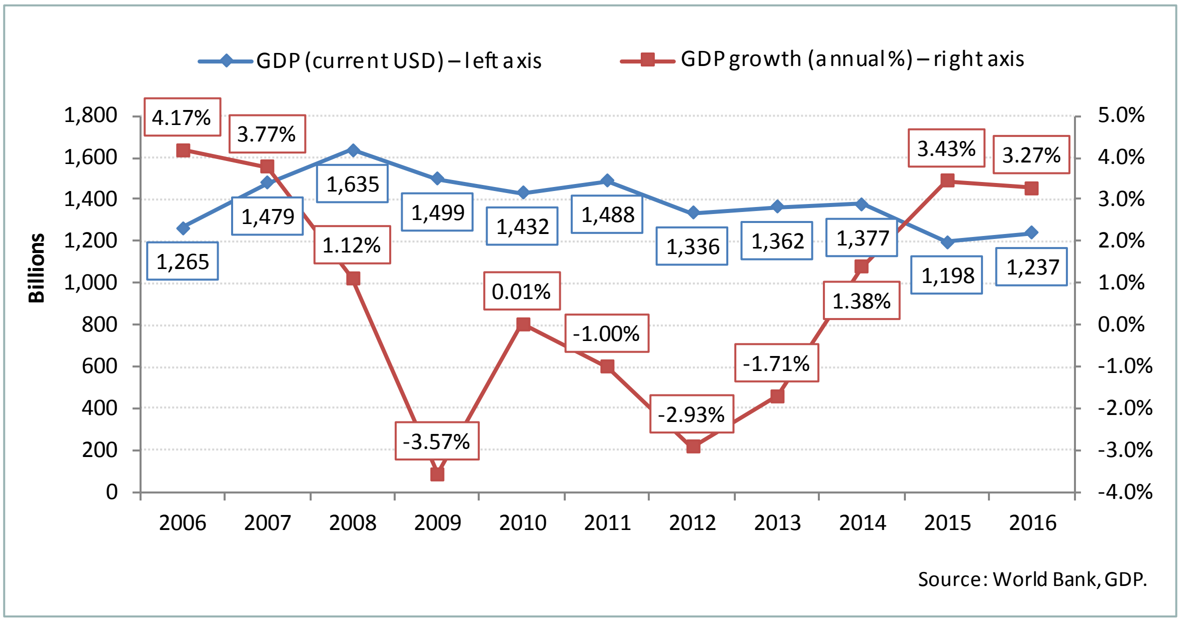


Figure 185
Spain: GDP



1.4.2.10. Canada

Figure 186
Canada: Vehicles in Use

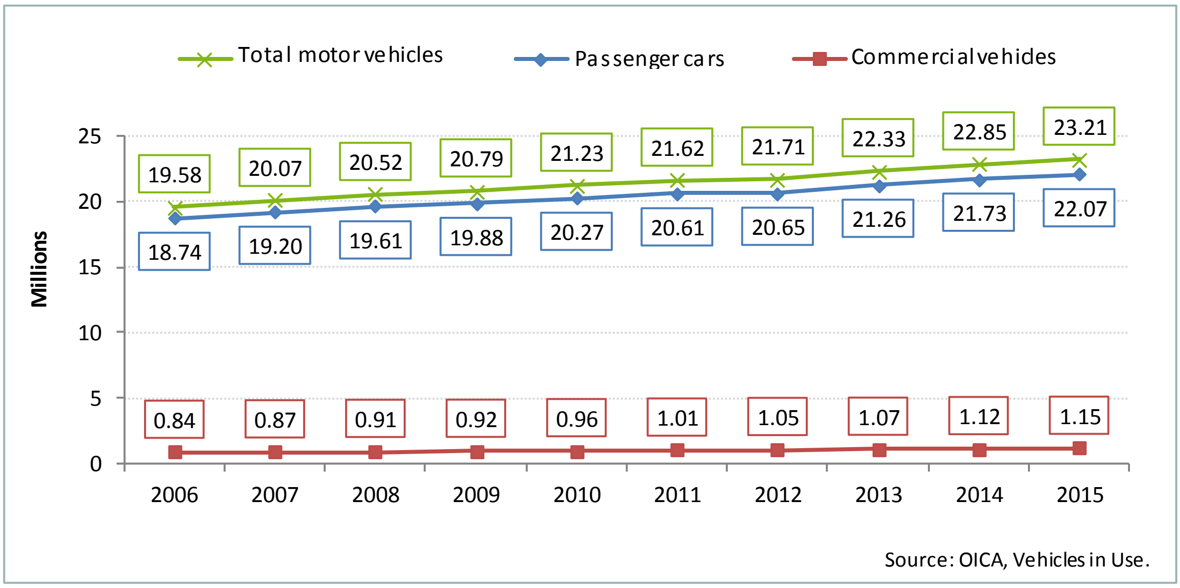
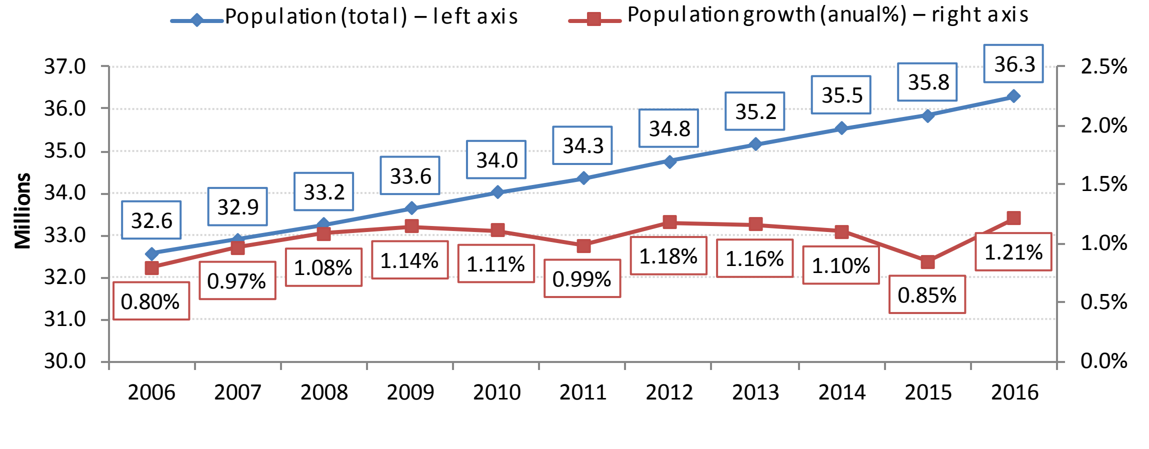
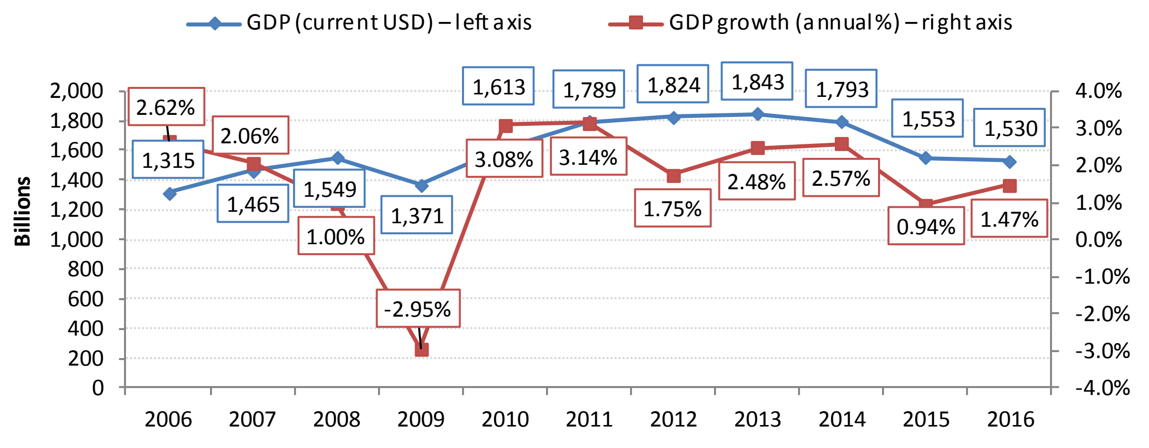


Figure 187
Canada: Population Statistics



Source: World Bank, Population Statistics.

Figure 188
Canada: GDP



Source: World Bank, GDP.

1.5. Research and Development Investment in the Automotive Sector

The automotive sector is one of the leading sectors in R&D investment. According to *The 2017 EU Industrial R&D Investment Scoreboard*,[35] in 2016, the auto industry provided 15.4% of total worldwide R&D expenses, surpassed only by the technology hardware and equipment sector (16.2%) and the health-care sector (19.4%) (European Commission 2017).

The various world regions have very different specializations and top sector mixes. The United States has 69% of its R&D in its top three sectors: software and computer services, pharmaceuticals and biotechnology, and technology hardware and equipment. Both the EU and Japan have the automotive sector as their top sector by amount of R&D, with a share of 53% in the EU and 29% in Japan. For the fourth consecutive year, the top R&D investor was Volkswagen (€13.7 billion). The second and third positions were taken by the US companies Alphabet (€12.9 billion) and Microsoft (€12.4 billion) (European Commission 2017).

The average growth in R&D spending in the EU was 7.0%, with the highest contribution to R&D growth coming from the same sectors as worldwide: ICT producers (+14.4%), ICT services (+12.7%), health industries (+7.9%) and automobiles (+6.7%). German R&D spending in the automotive sector grew 7%, more than the global average. In the United States, automotive R&D spending decreased by 0.6% and, in Japan, it increased by only 5.5%. These regions were surpassed by Chinese automobile firms, which posted an increase of 14.2% in the same year (European Commission 2017).

The good performance of EU R&D investment in the automobile sector (which made up 27% of total R&D spending in the EU) was due mainly to companies based in Germany and the United Kingdom. Automotive companies based in Germany increased their R&D investments by 9.7% in 2016, and firms based in the United Kingdom did so by 11.1%. French automobile firms posted an average increase of 5.1% in R&D expenses in 2016 (European Commission 2016).

Despite the trend toward being more reliant on suppliers for R&D, traditional large automakers are still among the world's top companies for R&D spending. According to the 2017 EU Scoreboard, the top 25 R&D investing companies in the world include seven automakers—Volkswagen (first), General Motors (11th), Daimler (12th), Toyota (13th), Ford (15th), Honda (21st), and BMW (23rd)—as well as one supplier, Roberto Bosch (20th) (European Commission 2017).

Given the ongoing changes in the industry, the automotive sector can be expected to continue to invest significantly in R&D.

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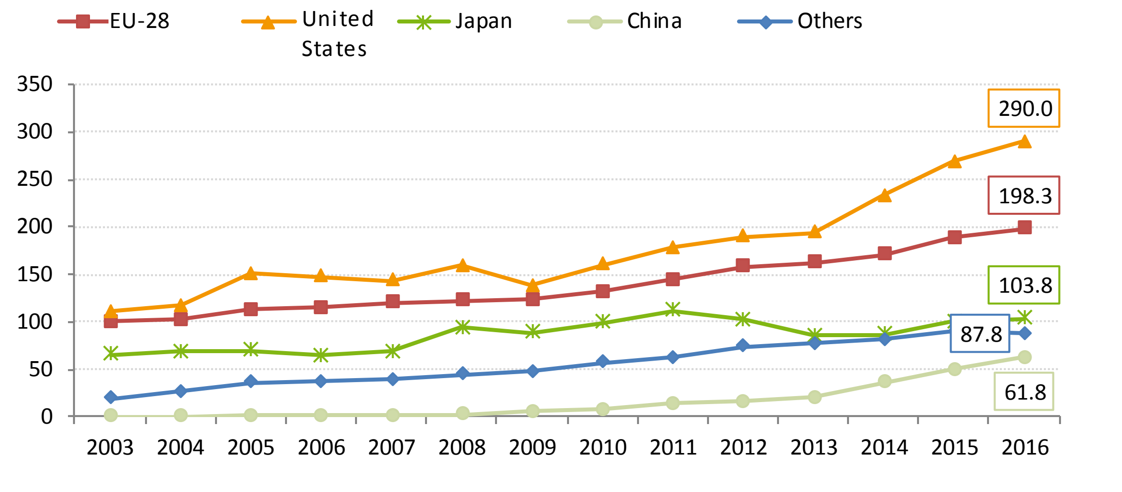
[35] The 2017 edition of the EU Industrial R&D Investment Scoreboard (the *Scoreboard*) analyzes the 2,500 companies investing the largest sums in R&D in the world in the fiscal year 2016/17. Published by the European Commission's Joint Research Centre (EC JRC), it comprises companies based in the EU (567), the United States (822), Japan (365), China (mainland) (376), Taiwan (105), South Korea (70), Switzerland (52) and a further 19 countries.

1.5.1. R&D Investment by Region in 2016

Figure 189

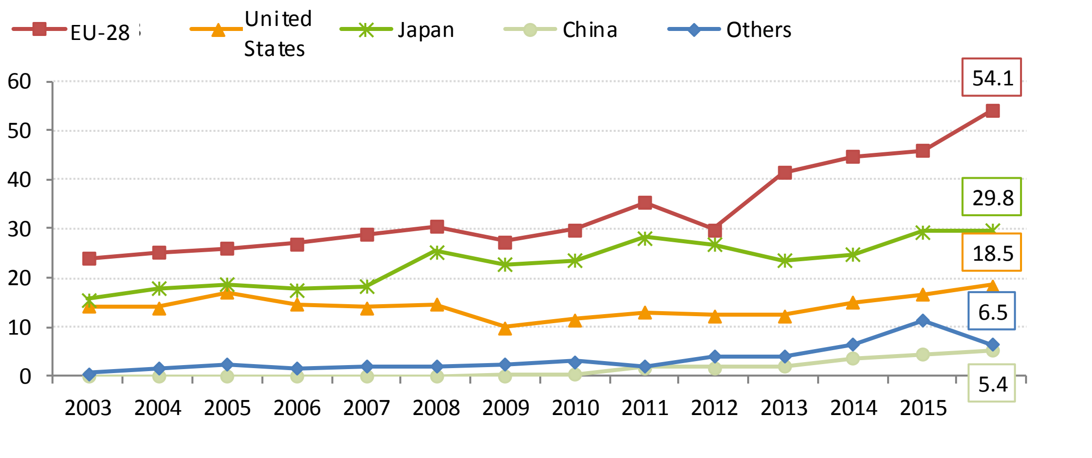
R&D Investment by Region (€ Million)



Source: European Commission Joint Research Centre, *The 2017 EU Industrial R&D Investment Scoreboard*.

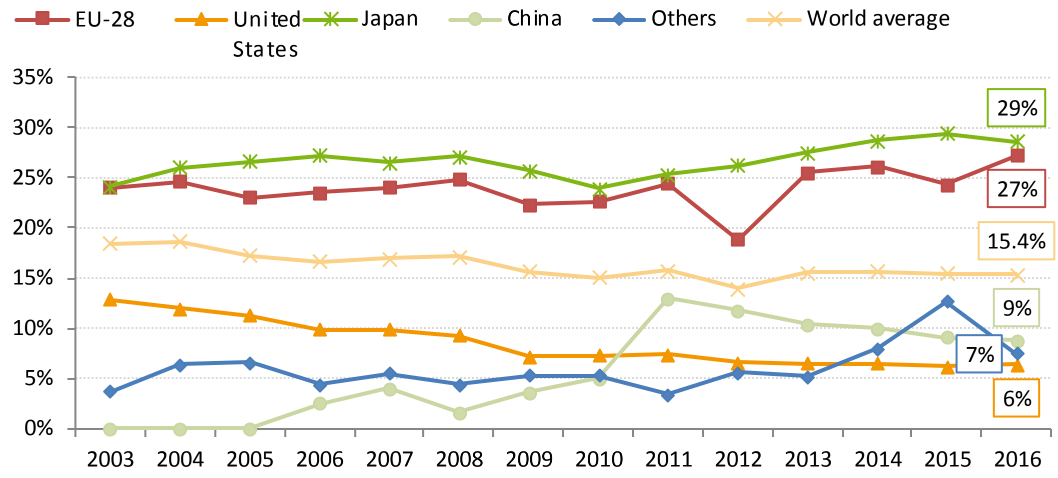
Figure 190

R&D Investment in Automotive and Parts by Region (€ Million)



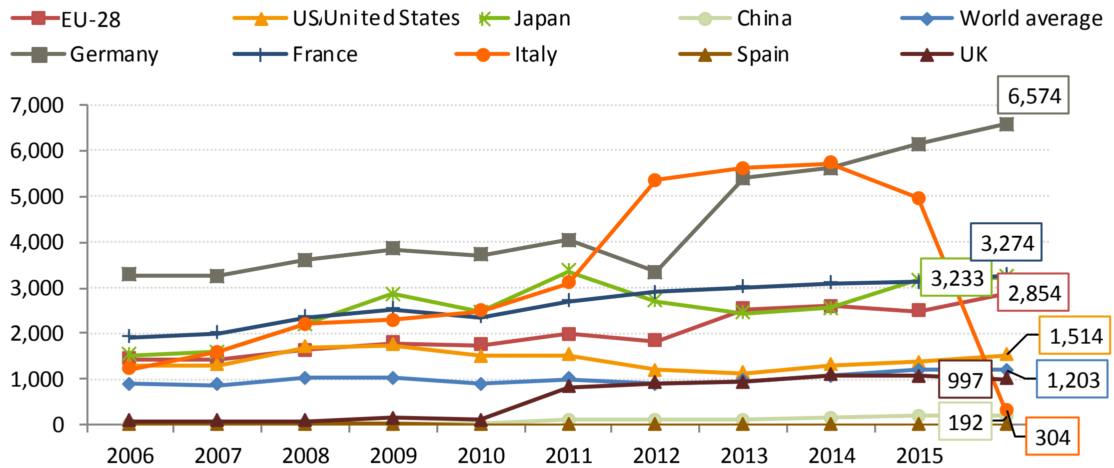
Source: European Commission Joint Research Centre, *The 2017 EU Industrial R&D Investment Scoreboard*.

Figure 191
Automotive and Parts as Percentage of Total R&D Investment



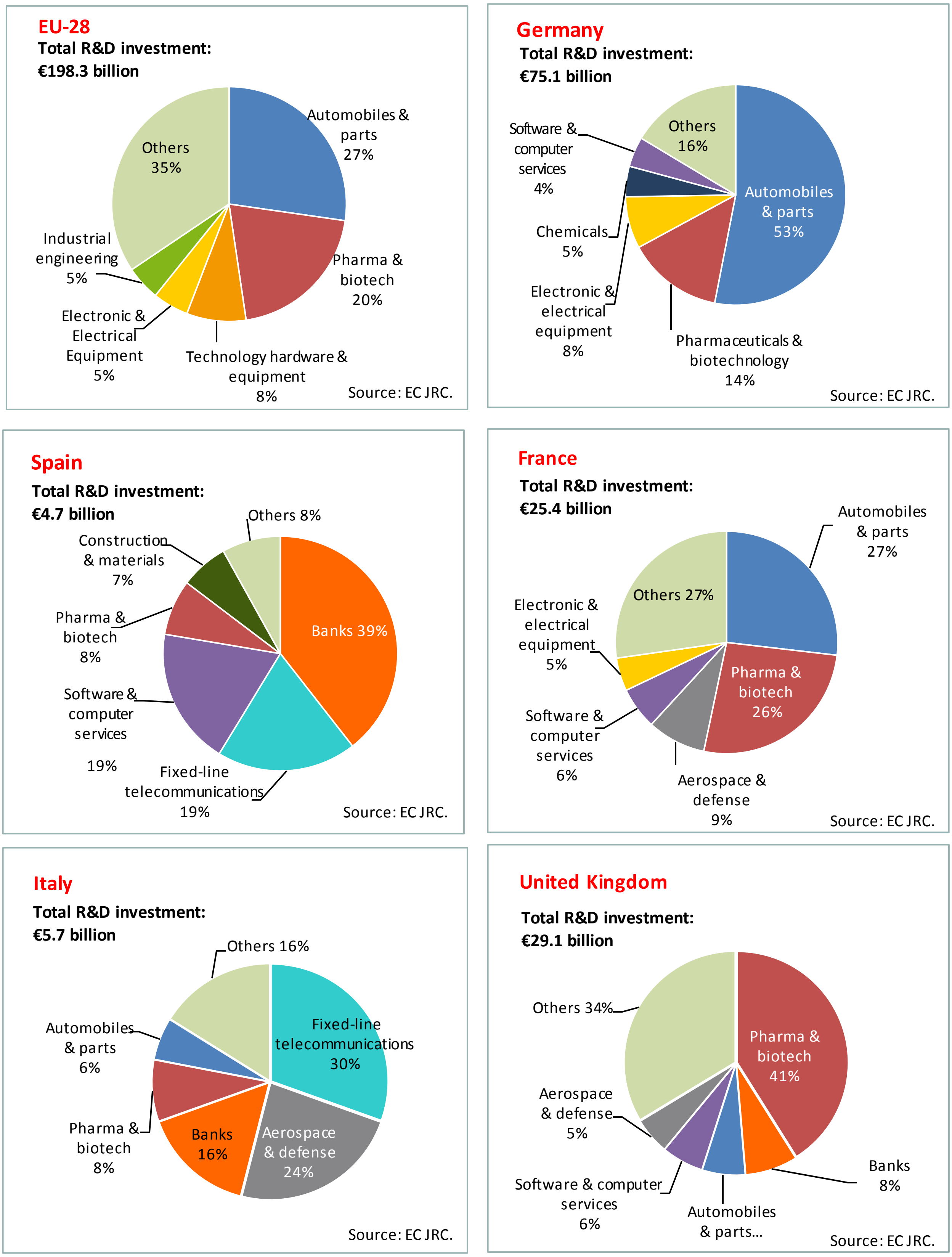
Source: European Commission Joint Research Centre, *The 2017 EU Industrial R&D Investment Scoreboard*.

Figure 192
Automotive and Parts R&D Investment per Vehicle Produced (€)



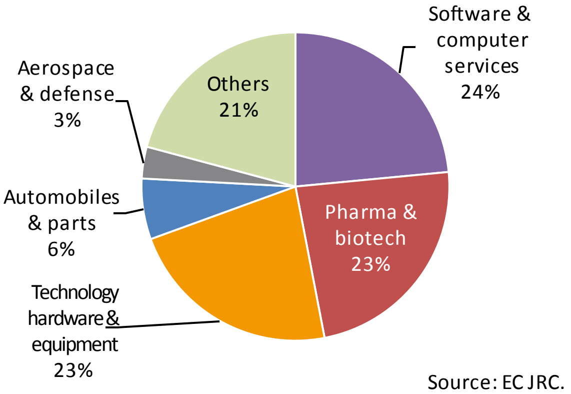
Sources: European Commission Joint Research Centre, *The 2017 EU Industrial R&D Investment Scoreboard*; OICA, production data.

Figure 193
R&D Investment by Industry for Selected Regions in 2016



United States

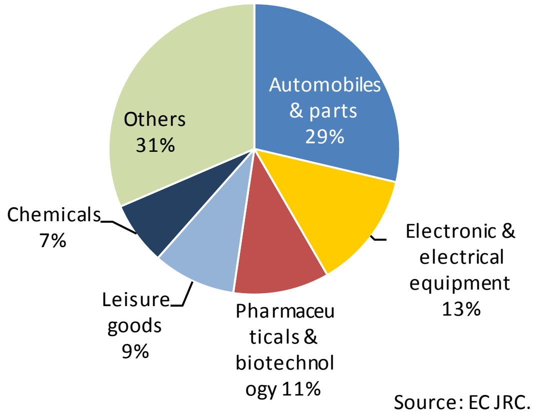
Total R&D investment:
€290.0 billion



Source: EC JRC.

Japan

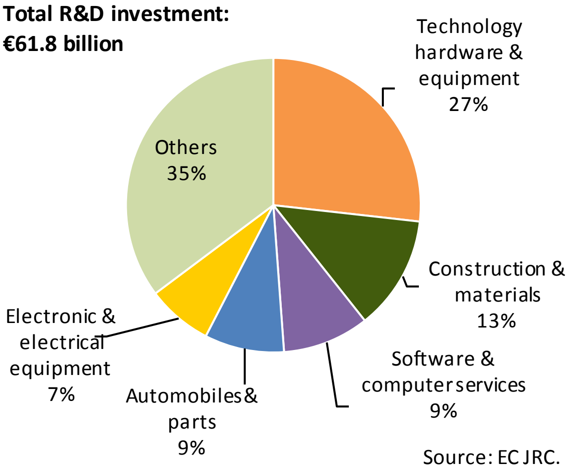
Total R&D investment:
€103.8 billion



Source: EC JRC.

China

Total R&D investment:
€61.8 billion

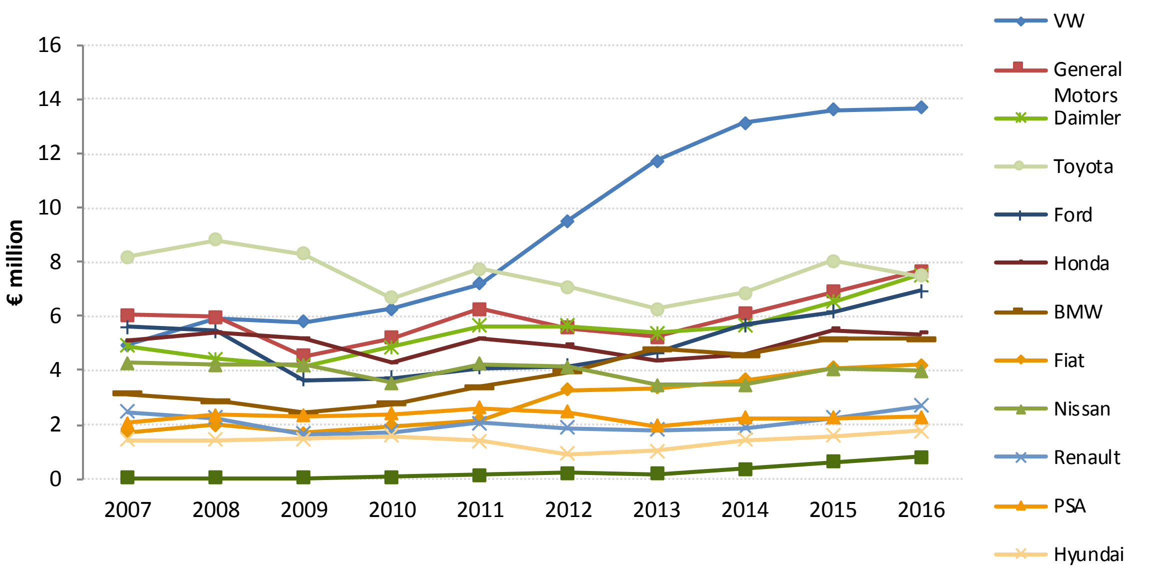


Source: EC JRC.

1.5.2. R&D Investment by Brand

Figure 194

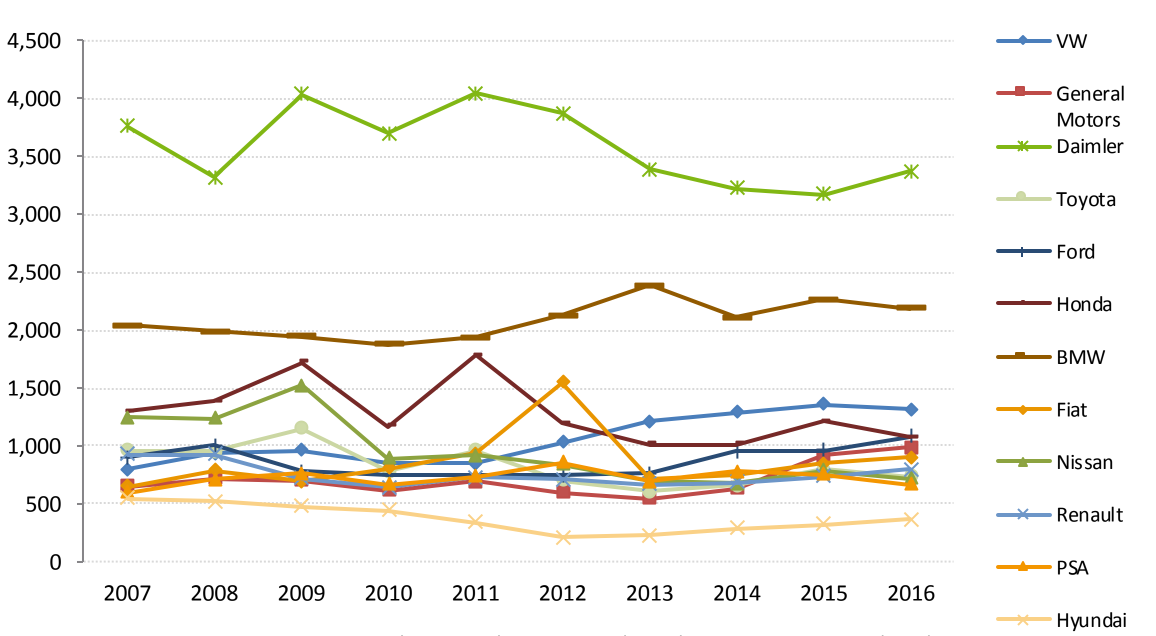
R&D Investment in Automotive and Parts by Brand



Source: European Commission Joint Research Centre, *The 2017 EU Industrial R&D Investment Scoreboard*.

Figure 195

R&D Investment per Vehicle Produced, by Brand (€)



Source: European Commission Joint Research Centre, *The 2017 EU Industrial R&D Investment Scoreboard*.

Since Tesla's R&D investment per vehicle produced is significantly higher than the average (given its small production volume and current ramp-up phase), its numbers are shown below in a separate table.

Table 2
R&D Investment per Vehicle Produced: Tesla (€)

2008	2009	2010	2011	2012	2013	2014	2015	2016
153,574	15,970	138,642	170,013	78,656	7,495	12,091	12,389	10,391

Sources: European Commission Joint Research Centre, The 2017 EU Industrial R&D Investment Scoreboard (http://iri.jrc.ec.europa.eu); Tesla annual reports.

1.5.3 Business Model Innovation

Since its early days, the automotive industry has been permeated by innovation, driven primarily by product differentiation and process efficiency, the pillars of its value creation and the key parameters of competition between automotive companies. Automotive companies distinguish themselves in terms of the products, relations and operations that define their global value chains (Sturgeon, Van Biesebroeck and Gereffi 2008)

As demographic and institutional changes reshape the world's landscape, many urban areas are starting to become a hostile environment for automobiles (Zegras 2015). If we take a closer look, however, it becomes clear that this is not (only) a matter of product inadequacy because merely replacing the current vehicle fleets in cities with environmentally friendly cars would not solve the challenges of congestion, gridlock, and parking space. The idea that green vehicles are the ultimate answer to institutional demands may be tempting but it falls short on delivery. Instead, most current salient problems of urban mobility boil down to one fundamental issue: the question of car ownership.

The growth of urban areas and the increasing number of megacities (of more than 10 million inhabitants) make it necessary to rethink mobility and find solutions that will be more efficient (efficiency is defined by the ratio of outputs and inputs). The private use of cars in densely populated areas sometimes produces inefficiency: for example, most car owners use their vehicle less than 10%[36] of the time. Valuable inputs in the form of assets and energy do not equate to quick and easy displacement from A to B – which is what they are meant for.

Overall, the car-ownership model's inefficiency is becoming prominent in the form of, for example, occupied parking spaces, heavy congestion, and numerous vehicles transporting only one person. Moreover, accidents as well as noise and air pollution are receiving more attention. In response to this, vehicle-use restrictions are expected to become more stringent as the level of urbanization rises, increasing the pressure for more efficient alternatives for personal mobility.

Recent advances in the fields of connectivity enable more efficient approaches to the use of personal, shared and public assets by linking unused assets to potential users through online communities. These platforms use technology to match capacity and demand, unlocking hidden resources and creating new forms of value. Vehicles that are not currently being used, are carrying

[36] UCLA Prof. Shoup, http://shoup.bol.ucla.edu/PayAsYouPark.htm

only one passenger or are driving around to find a free parking place are only some examples of situations that can be avoided or reduced and, in doing so, generate value for society.

The new value unit of mobility does not come in the form of a product (the vehicle itself) but in the form of a service offered by means of a vehicle. Some prominent examples include car sharing (e.g., BMW DriveNow) and ride hailing (e.g., DiDi). In other words, the value is transcending the product, and automakers are having to transcend their industry's boundaries as to capture it.

Today, most established OEMs are investing in new business models, many of which effectively promote less driving. OEMs are trying to build mobility ecosystems that will allow them to establish long-term relationships with their customers. The BMW Group's Now mobility services (DriveNow, ReachNow, ParkNow, and ChargeNow) may serve as an example. This approach is not free from challenges: for one, car-sharing models are at best barely profitable. (In its 2017 annual report, BMW reported losses of €17 million for DriveNow.) The models are focused on small cars, which result in small profits. These new business models are very different from the established business models of all OEMs and it can be difficult for automakers to reconcile two business models in the same organization.

Automotive companies have also entered the area of venture capital. The BMW Group is leading the way with its corporate venture-capital initiative iVentures, based in California' Silicon Valley. The fund's mission: "We find and grow cutting-edge technology companies redefining the automotive industry."[37] A look at the fund's web presence shows a very different culture from that found on the BMW Group's landing page.

While OEMs are only slowly starting corporate venture-capital initiatives, other companies based in Silicon Valley have been very successful at this over the past few decades. For example, both CISCO (https://www.ciscoinvestments.com) and Intel (www.intelcapital.com) have invested several billion dollars.[38]

Automotive companies invest significantly in R&D. In today's shifting landscape of changing product technology (e.g., electric power train), changing process technology (e.g., Industry 4.0) and changing business models (e.g., shared economy), OEMs will need to take a new approach to R&D. Automakers are thus trying to create mechanisms that will allow for corporate venture-capital initiatives to emerge and prosper as well as to attract and retain talent with an entrepreneurial spirit.

Corporate entrepreneurship is another burning topic in the automotive industry as companies strive to create and capture value in the emerging field of smart mobility solutions, particularly in urban environments. While some companies are exploring new opportunities through internal corporate ventures, other businesses have adopted a venture-capital approach to build their tech capabilities, investing seed capital across a variety of innovative firms that have the potential to deliver the next disruptive mobility solution. Dushnitsky and Lenox (2006) propose that corporate venture-capital investment creates greater firm value when used to harness novel technology and should form part of a firm's overall innovation strategy.

[37] BMW iVentures website, https://www.bmwiventures.com/, accessed May 4, 2018.

[38] As of September 2018, Intel Capital had invested $12.3 billion in 1,530 companies in 57 countries worldwide, and 660 portfolio companies had gone public or been acquired (www.intelcapital.com).

Another approach to capturing innovation is that of mergers and acquisitions. The automotive industry experienced an upward trend in M&A deals,[39] which culminated in 591 deals in 2015. In 2016, 583 deals were transacted with an aggregated disclosed value of $41 billion (PwC 2016). Europe maintained its position as the most active region, with 202 local deals. Only 7% of all the deals targeted vehicle manufacturers, while 37% of the deals targeted component suppliers, and 56% were categorized at targeting firms in “other” fields. The big “others” category suggests a strong movement of cross-industry M&A activity. In the past two years, Daimler, Volkswagen and BMW alone closed 32 deals involving start-ups in the new mobility field, with disclosed values adding up to more than $10 billion.

Another approach to innovation in OEMs is that of venture clients. BMW Startup Garage is an initiative in which the BMW Group assumes the role of the start-up’s client. Start-ups can focus on “an innovative technology, product or service that can make a significant contribution to BMW Group vehicles, services, factories and systems” (www.bmwstartupgarage.com).

The initiative enables the group to purchase “a first unit” of a new firm’s product, service or technology, thereby enticing the new venture with the role of supplier. This means that start-ups get a supplier status, supplier number, purchase order and revenue. Cleverly avoiding the “sharks” dilemma (Katila, Rosenberger and Eisenhardt 2008), the venture client takes no control of any intellectual property or equity, and new firms are not limited by exclusivity agreements. At the same time, this strategy prevents the new firm from becoming a competitor, and also—perhaps more importantly—eliminates a potential stepping stone for other established firms to enter the market through the acquisition of the new firm (Santos and Eisenhardt 2009).

The online application process for BMW’s Startup Garage is agile and pragmatic (www.bmwstartupgarage.com). When a start-up applies to join the program, those of the automaker’s internal clients with a strong interest in using the start-up’s technology in the start-up’s projects are identified. These clients then engage the start-up in the project, just like they would with any other technology supplier. The Startup Garage program’s duration is limited to 12 weeks, during which the new business idea or technology is incorporated and validated. After successful validation, BMW becomes a long-term client of the start-up. Further development and/or supplier agreements are then negotiated directly with the R&D and purchasing departments.

The automotive industry will continue to invest heavily in R&D, M&A, and partnerships. However, the loci of innovation will concentrate not only on product and process innovation but also on the innovation of business models.

[39] See section 2.2 for more details.

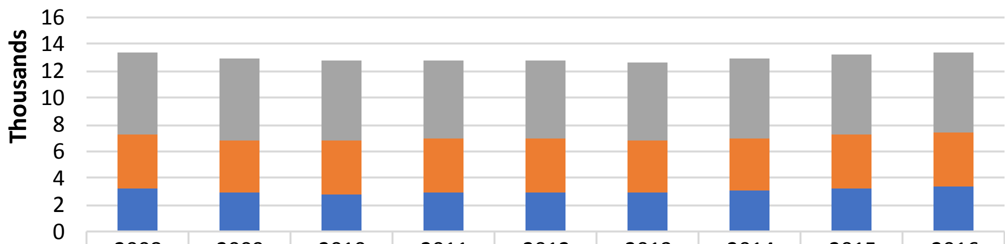
1.6. Employment Trends in the Automotive Sector

Due to the broad array of activities involved in the production, distribution and after-sales service of vehicles, the automotive industry generates a large number of jobs around the world: estimates are centered around four new jobs generated indirectly in the value chain for every worker directly employed by an OEM.[40] The following sections describe the employment trends in the auto industry by main region.

1.6.1. European Union

The people employed in the automotive industry in 2016 numbered approximately 13.3 million[41] in the European Union. Around 30% of the total jobs in the industry were generated in the segment of wholesale and retail trade, 26% corresponded to manufacturing of vehicles and their parts, and the remaining 45% to transport (Eurostat, Employment).

Figure 196
People Employed in the Automotive Sector: EU-28



	2008	2009	2010	2011	2012	2013	2014	2015	2016
Transport	6,110	6,053	5,920	5,933	5,890	5,844	5,879	5,892	5,959
Retail	4,146	3,995	3,994	3,924	3,931	3,860	3,902	3,999	3,968
Manufacturing	3,174	2,892	2,840	2,999	2,980	2,922	3,101	3,285	3,417
Total	13,430	12,939	12,754	12,856	12,801	12,627	12,883	13,175	13,344

Source: Eurostat, Employment. NACE Rev. 2: codes 29, 45, 49.
Notes:
1) Activities related to transport include rail and pipeline transport due to the lack of more disaggregated data. (NACE Rev. 2 codes were available only up to the two-digit level.)
2) Activities related to construction were not included due to the lack of more disaggregated data. (NACE Rev. 2 codes were available only up to the two-digit level.)

A more detailed picture shows that the segments employing the most people in 2012 (latest data available) were passenger land transport (2.4 million jobs), freight transport by road

[40] University of Michigan, "Automotive Industry Creates Four Jobs for Every Worker It Employs," March 15, 2001, http://ns.umich.edu/Releases/2001/Mar01/r031501d.html, and European Automobile Manufacturers Association (ACEA), "Employment Trends in the EU Auto Industry," June 18, 2018, https://www.acea.be/statistics/article/employment.

[41] Due to the lack of more disaggregated data, this figure includes passenger and freight rail transport, and transport via pipeline, in addition to passenger land transport.

(1.6 million jobs), and automobile dealerships (1.5 million jobs) (2012 data published by the European Automobile Manufacturers Association, 2015).

The total automotive employment (including manufacturing, services, and construction) totalled 12.1 million people, which was 5.6% of total EU employment. Automotive manufacturing employment accounted for 10.4% of all manufacturing employment in the EU, 7.6% being direct and 2.8% indirect automotive manufacturing employment. (See detailed figures in the table 3.) Direct automotive manufacturing provided 2.3 million jobs in the EU, of which 35% were in Germany, 11% in France, 7% in Poland, 7% in Italy, 6% in Romania, 6% in the Czech Republic, and 6% in Spain (2012 data published by the European Automobile Manufacturers Association, 2015). (The seven countries mentioned accounted for 78% of all direct automotive manufacturing jobs in the EU.)

Table 3
Detailed Employment Data in the EU Automotive Sector as of 2012 (in thousands)

2012		
Direct manufacturing	**2,297**	**19%**
Motor vehicles	1,042	(45%)
Bodies (coachwork), trailers and semitrailers	155	(7%)
Parts and accessories	1,100	(48%)
Indirect manufacturing	**828**	**7%**
Rubber tires and tubes	115	(14%)
Computers and peripheral equipment	71	(8%)
Electric motors, generators and transformers	232	(28%)
Bearings, gears, gearing and driving elements	196	(24%)
Cooling and ventilation equipment	214	(26%)
Automobile use	**4,299**	**35%**
Sale of motor vehicles	1,485	(34%)
Maintenance and repair of motor vehicles	1,493	(35%)
Sale of motor vehicle parts and accessories	704	(16%)
Retail sale of automotive fuel in specialized stores	458	(11%)
Renting and leasing of motor vehicles	159	(4%)
Transport	**4,067**	**34%**
Other passenger land transport	1,638	(40%)
Freight transport by road	2,429	(60%)
Construction	**626**	**5%**
Roads and motorways	565	(90%)
Bridges and tunnels	61	(10%)
Total	**12,117**	

Source: European Automobile Manufacturers Association 2015.

While many people tend to think about manufacturing when the automotive sector is mentioned, it should not be ignored that the distribution channel provides employment to a large number of individuals. A look at Europe's largest independent dealer groups can give an impression.

Table 4

Ranking of Europe's Biggest Independent Dealers in 2015

	Company	Home country	Brands	Franchise points	New wholesale vehicles	New retail vehicles	Used vehicles	Total vehicles	2015 revenue in €bn
1	**Penska Automotive (Europe)***	United States	24	181		84,164	81,538	167,958	6.43
2	**Pendragon***	UK	21	191		114,000	169,000	283,000	5.98
3	**Emil Frey***	Switzerland	31	375	69,000	98,000	70,000	237,000	5.4
3	**Lookers**	UK	29	153		108,813	72,156	180,996	5.02
5	**Arnold Clark**	UK	23	196		83,813	175,526	259,339	4.62
6	**Inchcape Europe***	UK	15	180	35,000	73,000	60,000	168,000	4.5
7	**AMAG***	Switzerland	7	173	42,500	59,000	59,000	160,500	4.12
8	**Vertu**	UK	24	122		186,348	71,702	158,050	3.33
9	**Møller Bil***	Norway	4	67	12,442	45,681	26,903	85,026	2.88
10	**D'Ieteren Motor**	Belgium	9	13	87,457	9,207	1,810	98,474	2.87
11	**Pon Holdings**	Netherlands	8	31	83,208	16,000	11,000	110,208	2.5
12	**Jardine Motors**	UK	22	71		35,067	26,338	61,405	2.3
13	**Bilia**	Sweden	9	94		41,102	37,542	78,644	2.18
14	**Marshall Motor Group**	UK	23	76		35,103	27,699	62,802	1.7
15	**JCT600***	UK	18	49		34,000	30,600	64,600	1.58
16	**AVAG Holding SE**	Germany	14	147		48,754	47,922	96,676	1.57
17	**Gottfried Schultz**	Germany	8	48		31,493	28,620	60,113	1.53
18	**Louwman**	Netherlands	14	63	35,266	9,541	14,649	59,456	1.5
19	**Listers**	UK	14	45		32,245	19,216	51,461	1.48
20	**Alcopa**	Belgium	21	44	41,000	22,000	9,000	72,000	1.38
21	**Salvador Caetano***	Portugal	24	147		50,817	26,261	77,078	1.3
22	**Greenhous**	UK	9	18		55,445	10,785	66,230	1.21
23	**Gueudet**	France	8	120		32,000	30,000	62,000	1.2
24	**Feser, Graf & Co.**	Germany	8	45		26,184	27,642	53,826	1.2
25	**Senger Group GmbH**	Germany	10	63		14,446	15,103	29,549	1.16
26	**Stern**	Netherlands	26	144		29,209	24,439	53,648	1.1
27	**Wellergruppe GmbH & Co. KG**	Germany	8	57		16,728	34,113	50,841	1
28	**Ridgeway Group**	UK	13	30		15,918	14,450	30,368	0.99
29	**John Clark Motor Group**	UK	13	29		13,566	11,759	25,325	0.975
30	**Bernard**	France	7	57		30,130	25,000	55,130	0.974
31	**Autobinck***	Netherlands	13	27	7,000	14,500	10,000	31,500	0.92

	Company	Home country	Brands	Franchise points	New wholesale vehicles	New retail vehicles	Used vehicles	Total vehicles	2015 revenue in €bn
32	**Group 1 Automotive**	UK	4	20		15,974	21,462	37,436	0.91
33	**Quadis**	Spain	29	110		20,883	12,779	33,662	0.84
34	**BYmyCAR**	France	14	32		29,300	19,500	48,800	0.83
35	**LöhrGruppe**	Germany	8	50		13,584	16,305	29,889	0.82
36	**Dello-Dürkop-Hansa Group**	Germany	18	98		20,000	24,000	44,000	0.8
37	**Harwoods**	UK	5	16		7,134	5,309	12,443	0.762
38	**Perrys Group**	UK	15	64		24,502	21,703	46,205	0.758
39	**Benfield Motor Group**	UK	12	35		28,143	16,462	44,605	0.753
40	**AHG**	Germany	8	60		13,600	17,100	30,700	0.75
41	**Car Avenue**	France	14	55		22,650	18,000	40,650	0.75
42	**VV Auto***	Finland	5	11	16,500	6,700	4,800	28,000	0.748
43	**Lueg**	Germany	8	31		12,381	11,295	23,676	0.74
44	**Cambria Automobiles**	UK	15	43		11,388	14,945	26,333	0.713
45	**Helston Garages**	UK	13	38		11,475	7,570	19,045	0.712
45	**Eastern Western Motor Group***	UK	13	27		11,500	8,000	19,500	0.712
47	**Chopard Lallier**	France	14	33		20,000	23,000	43,000	0.7
48	**Jean Rouyer**	France	16	48		19,782	20,425	40,207	0.69
49	**Neubauer**	France	22	73		19,723	10,139	29,862	0.685
50	**Pentagon**	UK	14	39		30,882	11,029	41,911	0.67

Source: ICDP. Ranking based on 2015 revenue.
* Includes estimates.
Note: Since it became a subsidiary of VW AG in 2011, Porsche Holding Salzburg—the largest and most successful automotive distributor in Europe—is not considered to be an independent dealership and hence is not included in the above list.

1.6.2. United States

The number of people employed in the automotive industry in the United States totaled 4.23 million in 2017, still following an upward trend after having passed precrisis levels (2007: 4.07 million) for the first time in 2015 (4.12 million). The segments employing the most people were automobile dealerships (1.3 million) and the manufacture of motor vehicle parts (0.59 million) (US Bureau of Labor Statistics, Automobile Sector[42]).

On top of the direct and indirect employment generated by the sector, the most recent study conducted by the Center for Automotive Research (2015) estimates that another 3.4 million jobs were created in 2014 because of the spending of direct and indirect employees in the sector. Considering these expenditure-induced jobs (or spin-off jobs), the auto industry is expected to have contributed to the creation of 7.4 million jobs in the United States in 2014 (Center for Automotive Research, 2015).

Regarding dealerships, total dealership revenues in the United States were $59.6 billion in 2016, a 5% increase from 2015. Of the total, 58% of the sales were new-vehicle sales, while 30% were used-vehicle sales, and the rest were service, parts, and body-shop sales. It is worth noting that, since 2010, the share of used vehicles in total dealership sales has been on the decline, in line with the US economic recovery from the crisis (2011: 32%; 2013: 31%) (NADA, Dealership Data).

Table 5
Number of People Employed in the Automotive Sector in the United States (Thousands)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Manufacturing motor vehicles and parts	**968**	**794**	**661**	**694**	**745**	**799**	**855**	**896**	**929**	**956**	**959**
Motor vehicle manufacturing	221	176	148	155	165	172	195	201	207	218	213
Motor vehicle bodies and trailers	158	117	104	106	116	130	137	144	150	151	156
Motor vehicle part manufacturing	589	501	410	433	464	497	523	552	573	587	589
Wholesale trade of motor vehicles and parts	**349**	**325**	**309**	**309**	**318**	**322**	**326**	**326**	**333**	**334**	**340**
Retail trade of motor vehicles and parts	349	325	309	309	318	322	326	326	333	334	340
Motor vehicle and parts dealers	**1,888**	**1,697**	**1,605**	**1,650**	**1,707**	**1,748**	**1,815**	**1,884**	**1,951**	**1,988**	**2,011**
Automobile dealers	1,233	1,068	998	1,031	1,072	1,108	1,157	1,211	1,263	1,287	1,301
Other motor vehicle dealers	162	142	123	122	121	124	131	134	143	145	148
Auto parts, accessories, and tire stores	492	487	484	497	514	516	527	540	546	556	562
Automotive repair and maintenance	**869**	**814**	**788**	**800**	**823**	**831**	**853**	**872**	**904**	**910**	**926**
Total	**4,074**	**3,629**	**3,363**	**3,453**	**3,593**	**3,700**	**3,848**	**3,979**	**4,118**	**4,188**	**4,237**

Source: US Bureau of Labor Statistics, Automobile Sector. URL: https://www.bls.gov/iag/tgs/iagauto.htm

[42] https://www.bls.gov/iag/tgs/iagauto.htm

Table 6
Average Light-Vehicle Dealership Profile

	2010	2011	2012	2013	2014	2015	2016	2017
Total dealership sales ($)	35,282,096	41,488,006	44,434,376	49,278,573	52,494,226	56,723,576	59,590,891	59,672,779
Total dealership gross profit ($)*	4,681,771	5,396,698	5,549,040	5,895,175	6,224,337	6,572,760	6,771,320	6,795,692
As % of total sales	13.3%	13.0%	12.5%	12.0%	11.8%	11.6%	11.4%	11.4%
Total dealership expense ($)	4,353,833	4,950,326	5,111,701	5,460,530	5,800,686	6,099,768	6,495,666	6,706,134
As % of total sales	12.3%	11.9%	11.5%	11.1%	11.0%	10.8%	10.9%	11.2%
Total operating profit ($)	328,967	446,301	437,339	435,685	444,464	472,981	275,662	91,774
As % of total sales	0.9%	1.1%	1.0%	0.9%	0.8%	0.8%	0.5%	0.2%
Net profit before taxes ($)	874,125	1,138,307	1,228,760	1,283,609	1,382,379	1,503,432	1,466,799	1,394,756
As % of total sales	2.5%	2.7%	2.8%	2.6%	2.6%	2.7%	2.5%	2.3%
New-vehicle department sales ($)	18,862,374	24,056,032	25,137,519	28,306,164	30,478,833	33,006,319	34,546,139	34,393,462
As % of total sales	53.5%	58.0%	56.6%	57.4%	57.6%	58.2%	58.0%	57.6%
New-vehicle average selling price ($)	29,930	30,982	31,194	32,035	32,824	33,456	34,449	34,670
Used-vehicle department sales ($)	11,525,205	13,267,905	13,868,561	15,173,243	16,256,538	17,240,887	18,109,934	18,106,032
As % of total sales	32.7%	32.0%	31.2%	30.8%	30.7%	30.4%	30.4%	30.3%
Used-vehicle average selling price ($)	16,480	17,311	17,556	18,081	18,839	19,400	19,886	20,009
Service and parts sales ($)	4,858,566	5,448,318	5,384,443	5,783,559	6,187,243	6,458,094	6,972,698	7,194,457
As % of total sales	13.8%	13.1%	12.1%	11.7%	11.7%	11.4%	11.7%	12.1%

Source: NADA, Dealership Data.
* Gross profit includes the cost of goods sold but not selling, general and administrative expenses (SG&A) or advertising.

1.6.3. China

In contrast to the European Union and the United States, which show moderate job creation in the auto sector, the number of employees in China's automotive industry showed significant growth in the decade up to 2012. Jobs in the sector rose from 1.6 million in 2002 to 2.4 million in 2011 and 4.2 million in 2012 (Statista 2012). These large increases are nothing but a reflection of how quickly the industry was growing in the decade in question.

Table 7
Number of People Employed in the Automotive Sector in China (Thousands)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1,570	1,605	1,693	1,669	1,855	2,041	2,094	2,165	2,203	2,417	4,249

Source: Statista (2012).

1.6.4. Japan

The number of people employed in the auto-related industries in Japan totaled around 5.34 million in 2016, representing 8.3% of the country's total employment (Statistics Bureau of Japan, Japan Employment Data). The segment employing the largest number of people was road transport, with 2.69 million jobs. This category includes road freight transport, road passenger transport, road transport-related services and vehicle rental services. The segment with the second-highest number of employees in 2016 was sales and services, with 1.03 million jobs (Japan Automobile Manufacturers Association 2015).

Table 8
Number of People Employed in the Automotive Sector in Japan (Thousands)

2008	2009	2010	2011	2012	2013	2014	2015	2016
5,279	5,534	5,477	5,504	5,530	5,571	5,511	5,499	5,344

Source: Statistics Bureau of Japan, Japan Employment Data.

Table 9
Employment in the Automotive Sector and Related Industries in Japan (2016)

Automobile manufacturing	**814,000**
Automobile manufacturing (including motorcycles)	188,000
Manufacture of auto parts and accessories	609,000
Auto-body and trailer manufacturing	17,000
Road transport	**2,694,000**
Road freight transport	1,714,000
Road passenger transport	560,000
Services related to road transport	371,000
Vehicle rental services	49,000
Automotive fuel, insurance, and recycling	**349,000**
Automotive fuel retailing	336,000
Auto damage insurance	12,000
Automobile recycling	1,000
Materials and equipment supply	**456,000**
Electric machinery and equipment	66,000
Nonferrous metals	22,000
Iron and steel	130,000
Metal products	41,000
Chemicals (including paints), textiles, and petroleum	31,000
Plastic, rubber, and glass	139,000
Electronic parts and equipment	21,000
Manufacturing machinery	6,000
Sales and services	**1,031,000**
Automobile retailing (including motorcycles, used vehicles, and auto parts and accessories)	577,000
Automobile wholesaling (including motorcycles, used vehicles, and finished/used parts and accessories)	190,000
Automobile servicing	264,000
TOTAL	**5,344,000**
SUBTOTAL (excluding materials and equipment supply)	**4,888,000**

Source: Japan Automobile Manufacturers Association 2017.

2. Key Trends & Challenges

This chapter uses the PESTEL[43] framework and sets out and discuss the key trends and challenges of the automotive industry in politics, economics, technology, society, the environment, and regulation. All information is as of **April 2018** unless stated otherwise.

2.1. Political Factors

2.1.1. United Kingdom (Brexit)

In a referendum held on June 23, 2016, 52% of voters supported the United Kingdom leaving the EU. The following year, the UK government invoked article 50 of the Treaty on European Union and since then it has engaged in negotiations with the EU to seek a smooth transition for the UK's withdrawal in March 2019. In October 2018, however, negotiations had not come to an agreement and uncertainties about the trade relationship between the EU and UK were increasing.

If the UK left the EU without a trade agreement, World Trade Organization (WTO) rules would apply to trade between them, subjecting exports of complete vehicles from the UK to the EU to tariffs of up to 10%. Similar tariffs would apply to imports into the UK, one of the most important export markets for German OEMs.

According to International Trade Centre statistics published in 2017, the United Kingdom's trade flows of product category number 87 (vehicles other than railway or tramway rolling stock, and parts and accessories thereof) in 2016 was as follows:

Automotive exports totaled €47 billion in 2016. The main export destinations for vehicles manufactured in the UK were the European Union (47% of the trade volume in US dollars), the United States (19%), China (10%), Australia (2%), Japan (2%), Turkey (2%), and others (18%). The value of automotive imports was 45% higher than the value of exports, totaling €68 billion. The great majority of imported vehicles came from the European Union (84% of the trade volume in US dollars), followed by Japan (4%), Turkey (3%), South Korea (2%), China (1%), the United States (1%), and others (4%).

The United Kingdom is the second largest producer of premium cars after Germany and the third largest car producer in Europe. According to the European Automobile Manufacturers Association (ACEA), in 2016 around 83% of the cars manufactured in the UK were exported. More than half (56%) of the vehicles were exported to the European Union. Therefore, Brexit tariffs would have a significant impact on automakers and suppliers. The table 10 lists the UK operations of the top manufacturers, showing their exposure to Brexit.

[43] PESTEL analysis describes a framework of macroenvironmental factors (political, economic, social, technological, environmental and legal factors) used in market research.

Table 10

Manufacturer	Models	Location	Production in 2016
Jaguar Land Rover	F-Type, F-Pace, XE, XF, XJ, Defender, Discovery, Discovery Sport, Evoque, Range Rover, Range Rover Sport	Castle Bromwich, Halewood, and Solihull	544,401
Nissan	Juke, Leaf, Note, Qashqai, Infiniti Q30	Sunderland	507,444
Mini (BMW Group)	Mini	Oxford	210,973
Toyota	Auris, Avensis	Burnaston in Derby	180,425
Honda	Civic, CR-V	Swindon	134,146
General Motors: Vauxhall	Astra	Ellesmere Port	118,182
Others	Aston Martin, Lotus, etc.		27,127
Total			**1,722,698**

Note: Ford builds engines in Dagenham and Bridgend for vehicles assembled in Europe.

Source: Society of Motor Manufacturers and Traders (2017).

2.1.2. United States

2.1.2.1. President Trump's Impact on OEMs and Tech Companies[44]

After beginning his 2016 presidential election campaign, the future US president Donald Trump announced several measures that would affect the auto industry, listed below:

Pressure to produce. Trump pushed automakers to build more plants and hire more workers. However, increasing capacity in the United States was not on the carmakers' agenda at the time. (Tesla seemed to be the only exception.)

Corporate tax cuts are part of the so-called "pro-growth" policies of the Trump administration and greatly benefit large companies such as OEMs.

Environmental regulations will become less stringent. In January 2017, the recently inaugurated Trump said that regulations had got out of hand. This was good news for automakers, as they continued to sell pickups and SUVs in the United States.

A **border tax** is likely to be imposed on vehicles and parts imported from Mexico, a country that has committed itself to becoming an auto-manufacturing powerhouse in the future. Trump threatened to withdraw from NAFTA, the trade agreement among the United States, Canada and Mexico, which was used heavily by automakers that had production and supply chains spread across the three countries. (See section 2.1.2.2 for more.)

[44] Wingfield and Wakabayashi (2017); US Department of Homeland Security (2015).

China is the biggest auto market outside the United States. US carmakers have profitable joint ventures with Chinese automakers, sanctioned by the Chinese government. Any destabilizing of trade relations with China could undermine this setup.

An immigration order restricting entry to the United States by citizens of seven predominantly Muslim nations and all refugees had a direct impact on jobs and hiring. A significant part of the tech community, which relies on highly skilled immigrants, vocally rejected the policy. Among automakers, Ford took the most outspoken stance against the executive order. General Motors said it would support those of its employees who might be affected. Fiat Chrysler said it had no comment.

Those seeking an H-1B visa faced an increase in the required minimum wage of $60,000 (established in 1989 and unchanged since then). The High Skilled Integrity and Fairness Act, introduced by Congresswoman Zoe Lofgren of California, would raise H-1B holders' minimum salary requirement to $130,000. The action was very unpopular among tech companies because they relied on the ability to hire high-profile foreigners at very cheap salaries. An annual report from the US Department of Homeland Security, published in 2015, showed that 65% of H-1B petitions approved in the 2014 financial year were for workers in computer-related occupations. Their wages were 25% lower than the average.

2.1.2.2. NAFTA

The North American Free Trade Agreement was signed by Canada, Mexico, and the United States. It came into force in 1994, creating a trilateral trade bloc of more than 500 million people in North America, with the goal of eliminating barriers to trade and investment.

Shortly after his election as president, Trump said he would begin renegotiating the terms of NAFTA in order to resolve the trade issues he had campaigned on and reduce the US trade deficit.

According to International Trade Centre statistics published in 2017, the US trade flows of product category number 87 (vehicles other than railway or tramway rolling stock, and parts and accessories thereof) in 2016 was as follows:

Automotive exports totaled €112.3 billion in 2016. The main export destinations for vehicles manufactured in the United States were Canada (39% of the trade volume in US dollars), Mexico (17%), the European Union (13%), China (9%), the United Arab Emirates (3%), the United Kingdom (3%), and others (17%). The value of automotive imports, however, was more than double the value of exports, totaling €257.5 billion. Vehicle imports came mainly from Mexico (26% of the trade volume in US dollars), Canada (20%), Japan (18%), the European Union excluding the UK (16%), South Korea (8%), China (5%), and others (7%). As for finished vehicles, the trade balance between the United States and the other NAFTA countries totaled –€59 billion in 2016. That is, the United States was a net importer of vehicles manufactured in Canada and Mexico.

Overall, out of 17.5 million vehicles sold in the United States in 2015, about 65% were produced there (34.4% of all the models).

The average total domestic content (according to the Kogod index)[45] of all 116 models assembled in the United States was as follows:

[45] The components of the index are based on research into the economic value of different components of auto manufacturing that was carried out by the Center for Automotive Research in Ann Arbor, Michigan. The index takes into account profit margin; labor; R&D; inventory, capital and other expenses; engine; transmission; body, chassis and electrical components. For details, see "Made in America Auto Index," www.american.edu/kogod/research/autoindex.

Table 11

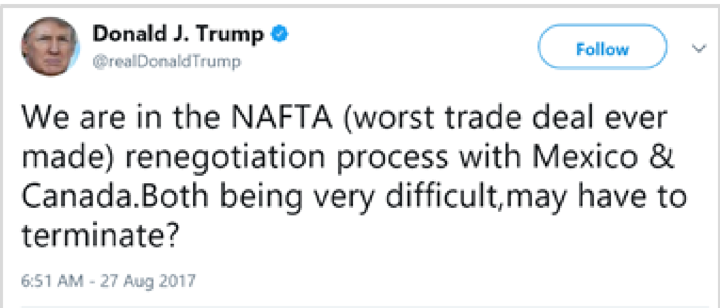
Manufacturer	Average of total domestic content
General Motors LLC	76.6%
Honda Motor Co., Ltd.	75.3%
Tesla (2015)	75.0%
Fiat Chrysler Automobiles	68.7%
Ford Motor Company	68.6%
Hyundai Motor Company	66.5%
Toyota	59.3%
Nissan North America, Inc	54.4%
Mercedes-Benz	45.5%
Subaru	42.5%
Kia Motors	39.7%
Volkswagen	37.7%
BMW AG	27.5%
Volvo	1.5%
Total	**61.9%**

Source: 2016 Kogod Made in America Auto Index (2017).

In short, President Donald Trump's agenda for NAFTA includes:

- A higher North American content requirement (> 62.5%)
- "Substantial" US content
- Stricter monitoring
- Tougher labor standards in Mexico

Although vague on the exact terms he was seeking in a renegotiated NAFTA, President Trump threatened to withdraw from negotiations if they did not process to his satisfaction.



Source: Twitter, @realDonaldTrump, August 27, 2017.

The final outcome of the negotiations was reached in October 2018 when the three countries reached a new deal, the United States-Mexico-Canada Agreement (USMCA). It gives the United States greater access to Canada's dairy market and allows extra imports of Canadian cars. The deal has 34 chapters and governs more than $1 trillion in trade. The new agreement is intended to last 16 years and be reviewed every six years. For the automotive sector, Canada and Mexico will have a quota of 2.6 million cars they can export to the United States if Washington decides to impose a 25% global tariff on car imports. Furthermore, 40% of car parts produced under the USMCA must be made in North America, on wages of $16 an hour.

2.2. Economic Factors

2.2.1. Mergers and Acquisitions (M&A) and Venture Capital Investments[46]

With the rise of new technologies and business models in the past several years, large players in the automotive value chain have started to establish partnerships, investing, or acquiring firms that develop smart-car technologies and mobility services.

The tables below show the main deals of each manufacturer in the past two years.

Type of deal

A	=	acquisition
CM	=	corporate minority
P	=	partnership
VC	=	venture-arm investment

Area of expertise

AD	=	autonomous driving
C	=	connectivity
DM	=	diverse mobility
EV	=	electric vehicles
F	=	financing and aftermarket
IND	=	Industry 4.0 and manufacturing

[46] CB Insights ("VC Investments," 2017); Crunchbase (2017); MarketLine (2018); Techcrunch (2017).

Table 12
BMW

Type	$ million	Date	Company	Field	Description
VC	51,00	Jan. 15	Moovit	C	Route planning
A	2.710,00	Dec. 15	Here	C	A mapping application originally developed by Nokia
P		Dec. 15	Baidu	C	China's Internet search giant
VC	13,50	Feb. 16	Zendrive	DM	"Using mobile tech and big data, it brings driver-centric analytics to the on-demand driving economy"
VC	11,70	Apr. 16	RideCell	C	Helps to manage fleets, "from knowing where each car is located, to which ride may have a low battery, to the vehicles "that need to be washed or are damaged"
VC	22,60	May 16	ChargePoint	EV	"The world's largest and most open electric-vehicle charging network," with more than 28,000 stations
VC	5,10	May 16	Scoop	DM	A carpooling service
VC		June 16	Parkmobile	C	Parking-management solutions, pay-by-phone parking and digital parking
VC		July 16	Rever	C	Connects a global community of motorcycle enthusiasts
VC	81,00	Sept. 16	Carbon 3D	IND	3-D manufacturing
VC		Oct. 16	Nauto	C	Upgrades cars "to get network and safety features previously only available in high-end luxury cars"
VC	5,00	Dec. 16	STRIVR	AD	"Uses virtual reality to help individuals learn and improve their performance"
VC	45,00	Jan. 17	Desktop Metal	IND	Metal additive manufacturing and 3-D printing
VC		Feb. 17	Fair	F	A car-leasing application platform based in the United States
VC	45,00	Feb. 17	Desktop Metal	IND	Desktop Metal is an industrial three-dimensional (3-D) printing company
VC	10,00	Feb. 17	Skurt	DM	An application that offers rental cars
VC	82,00	Mar. 17	ChargePoint	EV	ChargePoint Inc., formerly Coulomb Technologies Inc., designs, builds and supports electric-vehicle charging services. It also provides data to drivers on the web, a mobile app and in car navigation units
VC	5,00	Apr. 17	Bus.com	DM	Bus.com, formerly Sharethebus, is a Canada-based platform for organizing charter bus trips.
VC	55,00	June 17	Proterra	EV	A US-based designer and manufacturer of electric buses
VC	15,00	June 17	Xometry	IND	A US-based provider of professional 3-D printing, computer numerical control (CNC) machining, and proprietary technology to build parts and prototypes on demand
VC	159,00	July 17	Nauto	AD	Palo Alto-based Nauto, founded in 2015, is "an automotive technology company whose AI-powered device and smart cloud system make driving safer, easier and more efficient"

Table 12 (continued)

Type	$ million	Date	Company	Field	Description
VC	38,00	July 17	Shift Technologies	F	An online peer-to-peer used-car marketplace
VC		Aug. 17	Caroobi	C	A German online platform that allows users to book car-repair services
VC	10,00	Sept. 17	DSP Concepts	C	"A global developer of embedded audio digital signal processing solutions"
VC		Oct. 17	Fair	F	A car-leasing application platform based in the United States
VC	31,57	Dec. 17	GaN Systems	EV	"A developer of gallium nitride power switching semiconductors"
Total	**Count: 27; Sum of disclosed deal values: $3,395.47 million**				

Table 13
Daimler

Type	$ million	Date	Company	Field	Description
A	100,00	Sept. 14	RideScout	DM	Developer of a US-based trip-planning smartphone app
			Intelligent Apps GmbH		Operator of Mytaxi, a taxi-hailing platform based in Germany
VC	50,00	June 15	Zonar Systems	C	"Electronic fleet inspection, tracking and operations solutions for public and private fleets"
A	2,70	June 15	GlobeSherpa	C	Mobile ticketing and tracking
A	2.710,00	Dec. 15	Here	C	A mapping application originally developed by Nokia
A		Apr. 16	ACCUmotive	EV	Vehicle-focused lithium-ion technology
A		Apr. 16	LiTec	EV	Large-scale lithium-ion battery cells
A	1.200,00	July 16	Athlon Car Lease	F	Rabobank's car-leasing arm
A	100,00	July 16	FlightCar	DM	"The world's first peer-to-peer car sharing company to operate at airports"
A	79,50	July 16	Hailo	DM	A taxi platform. In 2017, it merged with Mytaxi (bought in 2014)
VC	20,00	Aug. 16	Blacklane	DM	A chauffeur service portal
VC	9,48	Aug. 16	Matternet	AD	"An automated delivery network for goods, built on a network of UAVs [unmanned aerial vehicles] operating autonomously" and "coordinated with a proprietary software platform"
VC		Dec. 16	Flixbux	DM	"Connects major European cities and towns with its daily scheduled services and its comprehensive long-distance bus network"

Table 13 (continued)

Type	$ million	Date	Company	Field	Description
A		Jan. 17	PayCash Europe	C, F	A platform that "enables businesses to conveniently optimize processes for worldwide payments"
A	30,00	Jan. 17	Taxibeat	DM	A Greek "hail-a-cab smartphone app and taxi driver marketplace"
VC	82,00	Mar. 17	ChargePoint	EV	ChargePoint Inc., formerly Coulomb Technologies Inc., designs, builds and supports electric-vehicle charging services. It also provides data to drivers on the web, a mobile app and in car navigation units
P		May 17	Vivint Solar	EV	Vivint Solar (formerly V Solar Holdings Inc.) is engaged in the design, installation, maintenance and distribution of solar-energy solutions, primarily to residential customers.
VC	150,00	June 17	Careem Networks	DM	A provider of private-car booking services based in the United Arab Emirates
VC	46,00	July 17	Momenta	AD	A Chinese provider of "self-driving car software that applies deep learning to mapping, path planning and object recognition problems"
VC	30,00	Aug. 17	Volocopter	AD	"A Germany-based developer of electric vertical take-off and landing multicopters for use as air taxis"
VC	250,00	Sept. 17	Via	DM	"Via is re-engineering public transit—from a regulated system of rigid routes and schedules to a fully dynamic, on-demand network. The Via algorithm matches, in real time, multiple passengers headed the same way with a single large SUV or van"
VC	92,00	Sept. 17	Turo	DM	Turo Inc. (formerly known as RelayRides Inc.) is a US-based online marketplace that allows car owners to rent out their cars
VC		Sept. 17	StoreDot	EV	StoreDot Ltd. develops and provides nanodots, microcrystals used for coating new-generation batteries and supercapacitors to improve the performance of a range of devices
VC		Oct. 17	Mobility House	EV	The Mobility House offers services related to electric vehicles, charging infrastructure, renewable energy as fuel, and access to public charging stations, among others. The company offers customized solutions for the automotive industry. Its headquarters are in Zurich, Switzerland
A		Jan. 18	What3words	C	A location pinpointing platform that helps users to find and communicate a location more accurately
VC		Jan. 18	Blacklane	DM	A chauffeur service portal that allows users to book rides on its website or using a smartphone application. The company is based in Germany.
Total	**Count: 26; Sum of disclosed deal values: $4,968.88 million**				

Table 14
Fiat Chrysler Automobiles

Type	$ million	Date	Company	Field	Description
P		May 16	Google	AD	The joint venture aims to "develop a fleet of autonomous 2017 Chrysler Pacifica hybrid people-movers"
P		Nov. 16	Amazon	C	"Amazon and Fiat Chrysler Automobiles (FCA) are going to start selling cars online [...] The program will start in Italy and be limited to three models, the Fiat 500, Fiat Panda, and Fiat 500L"
VC	101,00	Sept. 17	LeddarTech	AD	Leddartech Inc. "is an electronic company that develops and markets sensing solutions based on light emitting diode lighting systems." The company serves these sectors: industrial and manufacturing, transport, automotive, customer electronic and home appliances, smart building, smart lighting, entertainment, aeronautics, energy and the environment, defense and military, and aerospace. It markets its products through distributors worldwide. Its headquarters are in Quebec, Canada.
Total	Count: 3; Sum of disclosed deal values: $101 million				

Table 15
Ford

Type	$ million	Date	Company	Field	Description
VC	150,00	May 15	Lyft	DM	Bill Ford's venture fund invested in Lyft, a ride-hailing platform
VC	16,00	May 15	nuTonomy	DM	Bill Ford's venture fund invested in Singapore's nuTonomy, "the world's first driverless taxi service"
VC	182,20	May 16	Pivotal	C	Cloud-based software
VC	6,60	July 16	Civil Maps	C	"Converting the massive amounts of data coming in from the car's sensors into valuable and readable maps"
A		Aug. 16	SAIPS	AD	"Algorithmic solutions in image and video processing, deep learning, signal processing and classification"
VC	150,00	Aug. 16	Velodyne	AD	"Affordable lidar for self-driving cars"
P		Aug. 16	Nirenberg Neuroscience LLC	AD	Machine vision and artifical intelligence
VC	24,00	Aug. 16	Zoomcar	DM	An Indian car-rental and sharing platform
A	65,00	Sept. 16	Chariot	DM	Vans for commuting, with the route calculated automatically on demand
CM		Jan. 17	AutoFi	C	"A financing solution that plugs into a website to convert leads to online customers"
VC	1,00	Feb. 17	Argo AI	AD	An artificial intelligence company that focuses on computer science, robotics and self-driving vehicles
VC	3,00	May 17	Swiftly	DM	A developer of "enterprise software to help transit agencies and cities improve urban mobility"
VC	50,00	Jan. 18	Zoomcar	DM	An Indian car-rental company whose services include self-drive car rental and customer support services
Total	**Count: 13; Sum of disclosed valued: $647.8 million**				

Table 16
General Motors

Type	$ million	Date	Company	Field	Description
VC	5,79	June 14	GeoDigital	AD	"Laser-based solutions for field data acquisition, asset mapping and visual infrared inspection"
VC	20,00	Mar. 15	Sakti3	EV	"High performance, low cost and intrinsically safe solid-state battery technology"
VC	30,00	June 15	Proterra	EV	Design and manufacture of zero-emission vehicles for bus fleet operators
VC		July 15	Flinc	DM	An Internet- and app-based ride-sharing platform
VC	500,00	Jan. 16	Lyft	DM	A ride-hailing platform
A	36,30	Jan. 16	SideCar Technologies	DM	"A delivery and logistics company serving the on-demand economy"
A	1.000,00	Mar. 16	Cruise Automation	AD	"An aftermarket kit that allows users to convert certain types of cars into autonomous vehicles for highway driving"
CM		Oct. 16	Yi Wei Xing	DM	A "car-sharing technology solution provider" in China that is responsible for the Feezu app
P	250,00	Jan. 17	Girls Who Code	C	"A new model for computer science education, pairing intensive instruction in robotics, web design, and mobile development with high-touch mentorship"
P	85,00	Jan. 17	Fuel Cell System Manufacturing LLC	FC	A joint venture formed by GM and Honda to "mass produce hydrogen fuel cell systems to be used in 'future products' from each company"
VC	140,00	Jan. 17	Proterra	EV	A US-based designer and manufacturer of electric buses
VC		Feb. 17	NanoSteel	IND	A manufacturer of nanostructured steel alloys for industrial and automotive lightweighting applications
VC	159,00	July 17	Nauto	AD	Palo Alto-based Nauto, founded in 2015, is "an automotive technology company whose AI-powered device and smart cloud system make driving safer, easier and more efficient"
VC	10,00	Sept. 17	Ushr	AD	"A developer of high-definition (HD) mapping technology and software for autonomous and semi-autonomous vehicles"
A		Oct. 17	Strobe	AD	A provider of "light detection and ranging solutions" for unmanned vehicles
VC	13,50	Jan. 18	Seurat Technologies	IND	A manufacturer of metal printers
VC	14,00	Feb. 18	Yoshi	C	Delivery of fuel to customers' cars, wherever they are parked
Total	**Count: 17; Sum of disclosed valued: $2,263.59 million**				

Table 17
Honda

Type	$ million	Date	Company	Field	Description
VC		Dec. 16	Grab	DM	A ride-hailing service provider in Singapore
P	85,00	Jan. 17	Fuel Cell System Manufacturing LLC	FC	A joint venture formed by GM and Honda to “mass produce hydrogen fuel cell systems to be used in ‘future products’ from each company”
Total	**Count: 2; Sum of disclosed valued: $85.00 million**				

Table 18
Hyundai Kia

Type	$ million	Date	Company	Field	Description
VC	88,00	Sept. 16	Apttus	C	A software-as-a-service (SaaS) application provider that “renders enterprise-class applications for end-to-end management of business functions”
VC		Jan. 18	Grab	DM	A ride-hailing service provider. Its mobile application GrabTaxi allows users to search cabs available near their location and to book a trip by providing pick-up and drop-off locations. The company also provides on-demand carpooling services. Its GrabPay e-wallet solution lets users make payments at retail outlets
Total	**Count: 2; Sum of disclosed valued: $88.00 million**				

Table 19
PSA

Type	$ million	Date	Company	Field	Description
A		July 16	Autobutler	C	A Danish company that “provides information on automobile repair service providers that helps users in comparing service costs”
A		Dec. 16	CarJump	DM	Users can reserve and book cars from a choice of several car-sharing providers such as DriveNow, Car2go and Multicity. Later rebranded Free2Move
A	2.336,00	Aug. 17	Vauxhall/Opel		The Vauxhall and Opel car brands generated revenues of €17.7 billion ($18.8 billion) in 2016
VC	16,00	Feb. 17	TravelCar	DM	TravelCar is a France-based provider of a car-sharing service that “allows car owners to make their vehicle available for rent in airports, train stations and city centers”
Total	**Count: 4 Sum of disclosed valued: $2,352.00 million**				

Table 20
Toyota

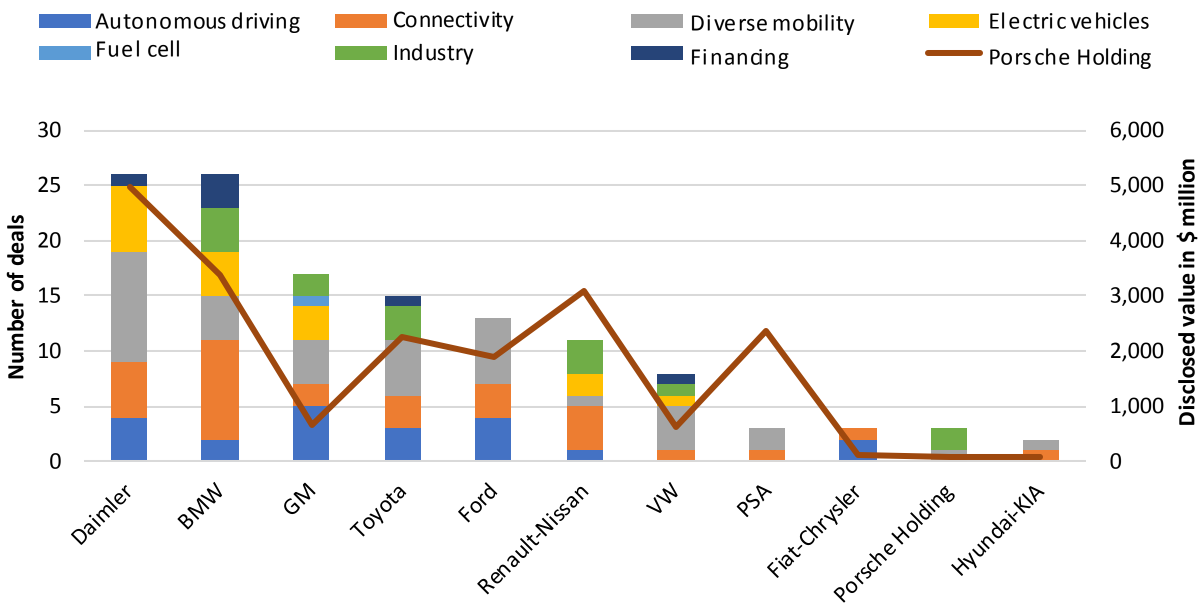
Type	$ million	Date	Company	Field	Description
VC	8,20	Dec. 15	Preferred Networks	AD	Applies "real-time machine-learning technologies to new applications in the emerging field of the Internet of Things"
P		Jan. 16	Kymeta	C	"Collaboration on a satellite antenna system that can send data to cars at broadband speeds"
VC	10,21	Jan. 16	UIEvolution	C	This software company, later rebranded Xevo, was set up "with the mission of creating immersive experiences that inform, entertain and engage"
P	100,00	May 16	Uber	DM	A ride-hailing platform
A		Sept. 16	Jaybridge	AD	A 16-member "robotics team with extensive experience automating industrial vehicles used in mining, rail and agriculture"
VC		Oct. 16	Nauto	C	Upgrades cars" "to get network and safety features previously only available in high-end luxury cars"
VC	10,00	Oct. 16	Getaround	DM	A US car-sharing company
A	260,00	Feb. 17	Bastian Solutions	IND	A provider of automated material-handling systems. The company offers supply-chain consulting and design, customer service and support, industrial controls and project-execution services
A		Feb. 17	Scratch Match	F	A provider of vehicle-body repair services
A	1.250,00	May 17	Vanderlande Industries	IND	A Netherlands-based provider of automated material-handling systems
VC	11,19	June 17	MaaS Global	DM	A mobility-as-a-service company based in Finland
A	27,00	June 17	Tachi-S	IND	A manufacturer of car seats
VC	159,00	July 17	Nauto	AD	Palo Alto-based Nauto, founded in 2015, is "an automotive technology company whose AI-powered device and smart cloud system make driving safer, easier and more efficient"
VC		Jan. 18	Grab	DM	A ride-hailing service provider. Its mobile application GrabTaxi allows users to search cabs available near their location and to book a trip by providing pick-up and drop-off locations. The company also provides on-demand carpooling services. Its GrabPay e-wallet solution lets users make payments at retail outlets
Total	**Count: 14; Sum of disclosed valued: $1,904.6 million**				

Table 21
Volkswagen

Type	$ million	Date	Company	Field	Description
A	2.710,00	Dec. 15	Here	C	A mapping application originally developed by Nokia
VC	28,00	Jan. 16	Silvercar	DM	Auto rental in airports. The start-up "already seems pretty tied to Audi—after all, every vehicle that Silvercar rents out is a silver Audi. Now the companies are deepening that relationship with a $28 million Series C investment"
VC	300,00	May 16	Gett	DM	A cab-hailing start-up
VC		Dec. 16	Hubject	EV	"An 'eRoaming' platform which aims to connect up EV charging stations and unify overall charging infrastructure for better mapping and easier payment solutions"
A		Dec. 16	PayByPhone	F	A Canadian mobile-payments company with an "app that lets you pay for parking (and parking tickets) with a smartphone"
A		June 17	Split	DM	A US-Finnish operator of a ride-booking application. "As a result of the acquisition, Split Finland Oy will become MOIA Finland Oy and will be refocused around the development for software and pooling algorithms for use in/with MOIA's ride-pooling concept service"
VC	32,00	Nov. 17	Shouqi Zhixing	DM	The Chinese operator of the electric-vehicle-sharing platform GoFun. The deal was led by the Chinese OEM Chery, with the participation of VW China
VC	14,00	Jan. 18	Seurat Technologies	IND	A manufacturer of metal printers, which intended to use the proceeds "to accelerate the commercialization of Seurat's breakthrough metal additive manufacturing technology"
Total	**Count: 8; Sum of disclosed valued: $3,038.00 million**				

Figure 197

Investments, Partnerships and Acquisitions of Key Manufacturers From Late 2014 to February 2018



Sources: CB Insights ("VC Investments," 2017); Crunchbase (2017); MarketLine (2018); Techcrunch (2017).

2.3. Social Factors

Demographic changes are reshaping urban landscapes and certain aspects—such as transportation—are affecting the quality of urban life. In terms of transport, the rapid urbanization process has brought problems such as traffic congestion, high parking fees, and air and noise pollution. There is an underlying lack of efficiency in urban mobility, and the car has played a central role in this issue.

At the same time, a shift is taking place in consumers' profile. As the Internet of Things provides constant contact with users, the relationship built up with consumers is extended beyond the time of purchase. Consumers' expectations of transportation now go beyond the product, and several companies have been emerging to offer alternative and efficient mobility solutions instead of a physical product. This is called "transportation as a service" (TaaS). The service is getting at least as important as the product. Differentiation among service providers may lie in customer experience and the level of seamless integration offered with other applications. In this new scenario, however, an even greater challenge for companies could be how to capture that value. New consumer behavior and emerging business models are shifting the traditional benchmarks of the automotive industry. (Automakers will measure not only volume sales but also the miles driven.)

All of these developments, in turn, aim to provide solutions to the challenges of urban mobility. They form an integral part of smart-city initiatives, with the objective of increasing operational efficiency and increasing general public welfare.

2.3.1. Transportation as a Service (TaaS)

> "The global car market is worth $2.3 trillion a year, of which Ford gets 6%, says Mark Fields, the firm's boss. The market for transport services is $5.4 trillion a year, he estimates, of which it gets near to "nothing"
>
> *(The Economist, September 2016)*

TaaS companies offer ride-hailing, on-demand delivery services, car sharing, bike sharing, and public transport services. The new approach to transport as a service relies on two interconnected trends: connectivity and the rise of the sharing economy. The first is related to the widespread use of smartphones and connected devices, which generate the data required to manage a system that combines a wide variety of public and private transport options and which allow firms to offer the information via an app. With the second factor—the rise of the sharing economy—the aim is to leverage the value of fixed assets such as apartments and cars when they are not being used. (For example, the average car is used only 10% of the time.) Young urban residents have become accustomed to "usership" instead of ownership, so they find the notion of transport as a service both natural and appealing, while the cost of owning a car in a city is steadily increasing. It is therefore not surprising that, between 1983 and 2014, the share of US residents aged 20 to 24 who had a driving license fell from 92% to 77%.[47]

In 2014, 54 per cent of the world's population lived in cities and two-thirds of the world population are expected to reside in cities by 2050[48]. Displacements in urban settings account for nearly two-thirds of all kilometers traveled by people. Therefore, most innovative concepts nowadays are aimed at urban commuters, seeking to solve the often inefficient mobility services in dense cities (including travel by foot, bike, public transportation, and car). Since each city has different requirements and limitations due to geography, culture, climate, safety, transit infrastructure, income per capita, etc., the spectrum of alternative and sometimes competing TaaS models is substantial. The authors believe that, although there is no general solution, individuals today definitely have a wider range of alternatives at their disposal, leading to different systems competing for share of wallet.

2.3.2. Platform Businesses: The Uber and DiDi Deal[49]

The market for on-demand mobility services seemed to be ruled by winner-takes-all and first-mover advantages. Following this logic, a leading mobility provider with a large user base would be hard to compete against. However, the TaaS market has low entry costs, and riders and drivers can switch between providers easily. Hence, the power of network effects should not be overstated.

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[47] Michael Sivak and Brandon Schoettle, Recent Decreases in the Proportion of Persons with a Driver's License across All Age Groups, The University of Michigan Transportation Research Institute, Report No. UMTRI-2016-4; http://www.umich.edu/~umtriswt/PDF/UMTRI-2016-4_Abstract_English.pdf

[48] United Nations, World Urbanization Prospects, UN DESA's Population Division, 2014, http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html

[49] Hook (2016); Kirby (2016); *The Economist* (August 2016).

Most Silicon Valley tech giants, ranging from Facebook to Google and Amazon, have failed to establish successful operations in China. Often government regulations have played a role, as the Chinese government is fully aware that the country's large population is unique in terms of the amount of data it can offer data-driven companies. Some companies, such as Uber, hoped to overcome the structural disadvantages and focused on trying to avoid the typical pitfalls. The threat of Chinese competitors seemed secondary. When Uber launched its service in China in early 2013, DiDi and Kuaidi, China's two largest taxi apps, were just two small companies with completely different business. However, DiDi and Kuaidi merged in February 2015. The new company attracted key investors such as China's Tencent and Alibaba as well as a $1 billion investment from Apple. (See section 2.3.3 below.) The plan was to target the private ride-hailing market with an aggressive subsidies strategy.

Even outside China, DiDi became a strong rival for Uber by forming alliances with several competitors, including Lyft in the United States, Ola in India, and Grab in Southeast Asia. The four companies also linked their apps, so that customers could access the others' car networks when traveling.

Uber tried to continue its China strategy but, eventually, on August 1, 2016, it agreed to hand over its Chinese operations to DiDi, in return for a 17.7% stake in the combined company's equity. The deal was a boon for both companies and was globally acclaimed as a wise move from Uber. It remains to be seen, however, when the companies will become profitable and harvest the significant investments they have put into growing their user base.

2.3.3. Apple[50]

Apple's $1 billion investment in DiDi Chuxing in May 2016 came amid rumors that the California-based technology giant was developing its own car (Project Titan), rumors that had started in early 2015. Since October 2016, however, Apple has apparently shifted its focus from producing a car to developing an autonomous driving system. A partnership with a company such as DiDi Chuxing, which employs thousands of drivers, could give Apple a resource for testing future software products.

According to Apple insiders, an autonomous driving system would give the US company more flexibility to either partner with existing carmakers or go back to designing its own vehicle in the future. Talking to Bloomberg about the project, Apple CEO Tim Cook said in June 2017 that his company was "focusing on autonomous systems" and that "it's a core technology that we view as very important. We sort of see it as the mother of all AI projects. It's probably one of the most difficult AI projects to actually work on." According to Cook, Apple was focusing on everything it would take to "view" the world around the car and coming to an understanding of what this meant in the context of navigation and safety.

Cook did not confirm or deny whether Apple was working to produce an "iCar," driverless or otherwise, or say whether the technology would be used by existing car manufacturers. "We'll see where it takes us," he said. "We're not really saying from a product point of view what we will do."

Given some of the current developments in the automotive industry and personal mobility as a whole, there is a unique opportunity to launch a car specifically designed for urban use. This car would be electric (no local emissions, easier to manufacture, more payload space), small (less

[50] Webb and Chang (2017); CB Insights ("44 Corporations," 2017); Painter (2018); Love (2016).

congestion, smaller battery), connected (data collection, new business models, customization via software or a smartphone) and, eventually, autonomous. Experts have estimated that such a purpose-designed car could be up to 25% cheaper than a traditional car.[51] For example, given the low speeds in urban environments it would not have to cover such a broad range of velocities, which in turn would reduce the need for complex passenger safety systems and allow for a smaller battery. Given the "customization by software or smartphone" approach, such an urban vehicle could be mass-produced on highly automated production lines, as passengers would use their mobile phones to differentiate the car via flexible screens mounted on the interior of the car. (Some of our millennial MBA students have said: "What do I care about the outside of a car? I'm looking at the inside!") This scenario would give rise to Foxconn-like first-tier suppliers, which could manufacture such a product for a company such as Apple and its 500 million-strong user base. If such a car were to be released by Apple then, given the company's stringent focus on customer experience, ease of use, a closed digital ecosystem and excellence in managing its supply base, it would be hard for established OEMs to launch products in this segment and take market share away from Apple.

Regardless of what the end product would look like, Apple has been developing something car-related, whether it is an autonomous driving system, an Apple car or simply an in-car entertainment system.

2.3.4. Samsung[52]

Another smartphone manufacturer that decided to diversify its business and get into the automotive business is Samsung, an industrial conglomerate. In November 2016, the group acquired the automotive equipment maker Harman (based in Stamford, Connecticut) in an $8 billion deal. Harman had started as Harman Kardon before Sidney Harman bought out his partner Bernard Kardon. In the 1950s Harman Kardon designed some of the first high-fidelity or hi-fi audio products. The company later acquired other labels, such as AKG and JBL. In the 2010s it started to invest in mobility and connectivity-related solutions. In 2016 Samsung decided to acquire Harman. It was a huge bet on connected technology in cars—and the biggest foreign takeover by a South Korean company. With this purchase, Samsung obtained an immediate foothold in the car-parts industry—and relationships with key carmakers such as the BMW and Volkswagen groups. Given this footing, Samsung can be expected to follow similar objectives as Apple, its main competitor in the smartphone market.

The Korean company also entered negotiations with Fiat Chrysler Automobiles (FCA) about acquiring stakes in the parts-making subsidiary Magneti Marelli in 2016, and in 2017 it was granted permission to begin testing self-driving cars in South Korea.

[51] McKinsey & Company, April 2017; https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry

[52] Etherington (2016); Samsung (2017); Shields and Newman (2017)

2.4. Technological Factors

2.4.1. Autonomous Driving

2.4.1.1. History

Autonomous driving has attracted a significant amount of attention over the past few years. However, it is not an invention of the 21st century. The first autonomous-car concepts appeared in the 1920s, and some experiments were conducted in the 1950s.

The first fully autonomous cars appeared in the 1980s. The Eureka Prometheus Project was a cooperation between Mercedes-Benz and the Bundeswehr University of Munich. The autonomous technology was entirely based on cameras. The project, led by Professor Ernst Dickmanns, had impressive results. In 1995, an autonomous Mercedes drove 1,700 kilometers from Munich to Copenhagen. The car reached a speed of 175 km/h and changed lanes around 400 times. The longest distance driven without any human intervention was 160 kilometers.

Today, autonomous test cars are equipped with laser scanners, radar sensors, and high-resolution navigation data. However, no automaker or tech company has yet driven such long distances at such high speeds on public highways (Bimbraw 2015).

Current developments focus on the artificial intelligence needed to process the data coming from different sensor technologies (infrared, radar, lidar, cameras, etc.) and on the development of cheaper sensors, in particular lowering the cost of lidar hardware. In this way, different companies approach the challenge from different angles: some rely on having total connectivity and therefore access to the cloud and its data and data-processing capabilities. Others focus on developing systems that work without any connection to 4G or 5G networks and that process all information locally. Hybrid solutions that blend the two approaches are the most widespread.

The holy grail of autonomous driving is to achieve so-called level 5 capabilities, meaning to have a car drive completely by itself with no human intervention required at all. At this point, no company has this capability and estimates differ as to when cars will be able to reach this level. Some Silicon Valley manufacturers give the impression that the technology is around the corner (although several drivers that believed these claims have been the victims of fatal accidents). However, traditional OEMs tend to estimate that full level 5, of a type that would also work in downtown Beijing or Shanghai, is at least a decade away. The complexities of level 5 autonomy become apparent when consideration is given to the wide range of scenarios under which cars operate: from deserted roads in Patagonia to heavy traffic jams in Beijing, from Arctic blizzards in Alaska to sandstorms in the Emirates, from the hilly streets of San Francisco to the 250 km/h trips on Germany's Autobahn. At this point, no system is available that can cover all these scenarios.

2.4.1.2. Terminology [53]

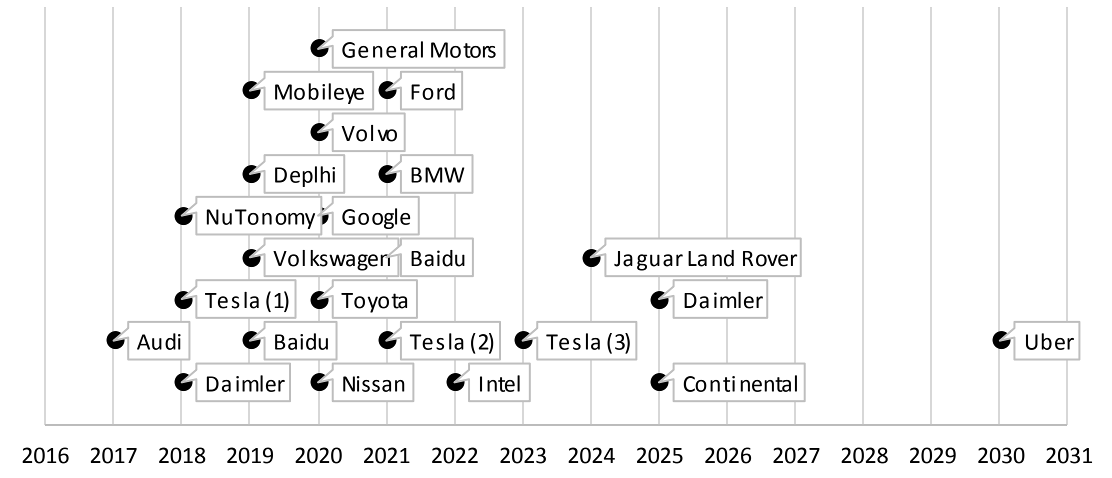
Levels of Autonomous Driving:

- **Level 0:** The automated system has no vehicle control but may issue warnings.
- **Level 1:** The driver must be ready to take control at any time. The automated system may include features such as adaptive cruise control, parking assistance with automated steering, and lane-keeping assistance type II, in any combination.
- **Level 2:** The driver is obliged to detect objects and events and respond if the automated system fails to respond properly. The automated system executes accelerating, braking, and steering. The automated system can deactivate immediately to let the driver take over.
- **Level 3:** In known, limited environments (such as freeways), drivers can safely turn their attention away from driving tasks but must still be prepared to take control when needed.
- **Level 4:** The automated system can control the vehicle in all but a few environments such as severe weather. The driver must enable the automated system only when it is safe to do so. When it is enabled, driver attention is not required.
- **Level 5:** Other than setting the destination and starting the system, no human intervention is required. The automatic system can drive to any location where it is legal to drive and make its own decisions.

2.4.1.3. Timing

Both automakers and Silicon Valley, as well as Chinese companies, aim to develop technology that enables autonomous cars to reach level 4 or 5. The graph below plots each firm's predictions for the launch of autonomous cars or services (note that many of these cars are level 3, at best):

Figure 198
Expected Launch of Self-Driving Product or Service



Source: See table bellow

[53] SAE International (2014).

Table 22

Company	Product or service	Launch date	Date of statement	Source
Audi	Self-driving A8	**2017**	October 22, 2014	(Torr 2014)
BMW, Intel and Mobileye	Forty autonomous BMWs in Munich and Jerusalem	**2017**	January 4, 2017	(Lambert 2016)
Daimler	Self-driving Mercedes trucks in production	**2018**	July 27, 2015	(Prigg 2015)
NuTonomy	Self-driving taxis in Singapore	**2018**	August 29, 2016	(Abbugao 2016)
Tesla (1)	Self-driving Tesla	**2018**	September 23, 2015	(Musk 2015)
Baidu	Develop self-driving cars for China together with Ford; mass-produce self-driving cars with Volvo	**2019**	January 29, 2016	(CNN, 2018; CNBC, 2018)
Deplhi	Fully self-driving system (SAE level 4)	**2019**	August 23, 2016	(Hawkins 2016)
Mobileye	Fully self-driving (SAE level 4) system	**2019**	August 23, 2016	(Hawkins 2016)
Volkswagen	Self-driving cars on the market	**2019**	April 23, 2016	(Frank 2016)
General Motors	Self-driving cars on the road	**2020**	May 10, 2016	(Stoll 2016)
Google	Self-driving Google car approved	**2020**	November 16, 2015	(Thompson 2015)
Nissan	Self-driving Nissan on the market	**2020**	August 27, 2013	(Nissan 2013)
Toyota	Toyota self-driving car	**2020**	October 8, 2015	(Caddy 2015)
Volvo	Death-proof semi-autonomous car	**2020**	January 22, 2016	(Thompson 2016)
BMW	Self-driving BMW iNext	**2021**	May 12, 2016	(Lambert 2016)
Ford	Self-driving Ford vehicles for mobility service fleets	**2021**	August 16, 2016	(Sage and Lienert 2016)
Tesla (2)	Approval of self-driving Tesla	**2021**	September 23, 2015	(Musk 2015)
Intel	Automated driving processors	**2022**	October 22, 2012	(Gaudin 2012)
Tesla (3)	"True autonomous driving"	**2023**	October 15, 2014	(Kaufman 2014)
Jaguar Land Rover	Self-driving Jaguar and Land Rover	**2024**	October 3, 2014	(Hawley 2014)
Continental	Automated driving systems	**2025**	December 18, 2012	(Continental 2012)
Daimler	Self-driving cars on the market	**2025**	January 13, 2014	(Daimler AG 2014)
Uber	Driverless Uber fleet	**2030**	August 18, 2015	(Goddin 2015)

The fulfillment of the predictions will depend not only on technology advances but also on regulation. The latter is beyond an automaker's control.

While affordability and liability are still unresolved issues for consumers, self-driving cars for autonomous mobility service fleets may be more likely in the short term. (Ford plans to provide autonomous vehicles for self-driving fleets by 2021.) The launch of mass-market autonomous cars will most likely happen gradually with the penetration and refinement of autopilot technology.

2.4.1.4. Testing Autonomous Cars: Europe (Fluhr 2017)

The legislation covering autonomous vehicles in Europe has its origins in the year 1968, when 36 countries signed the Vienna Convention on Road Traffic, which specified that human drivers must have full control over their vehicle at all times. In April 2016, the EU transport ministers signed the Declaration of Amsterdam, which stated that a common objective was to regulate intelligent traffic throughout the European Union by 2019.

In March 2017, the German parliament passed a law to allow autonomously driven cars to be active on German streets. The vehicle's own control system would be allowed to drive in certain situations and for certain periods of time but responsibility for mishaps would continue to rest firmly in the hands of the driver (who should be able to take control of the vehicle at any time). The law also requires self-driving cars to carry a black box to record all driving data, which would be decisive in disputes over liability should the autonomous-driving technology fail. Legislation often moves more slowly than the technology itself but the German government moved quickly to support the pioneering role of German automakers.[54]

Close collaboration between governments and automakers is crucial for the development and implementation of driverless technologies. Each manufacturer chose a strategic location for testing its autonomous vehicles on public roads in 2017:

Volvo	Göteborg, Sweden
Daimler	Munich, Germany
BMW	Munich, Germany
VW Audi	Munich, Germany
Nissan	London, United Kingdom
Ford	Essex, United Kingdom; Aachen, Germany

[54] German parliament, March 30, 2017, https://www.bundestag.de/dokumente/textarchiv/2017/kw13-de-automatisiertes-fahren/499928

2.4.1.5. Testing Autonomous Cars: United States[55]

In 2015, five US states (California, Florida, Michigan, Nevada and Virginia) and Washington, DC, allowed the testing of fully autonomous cars on public roads.

The Department of Motor Vehicles of the State of California adopted autonomous-vehicle testing regulations on May 19, 2014, and these became effective on September 16, 2014. As of January 25, 2017, the department had issued Autonomous Vehicle Testing Permits to the following entities, among others: Mercedes-Benz,* Google,* Delphi Automotive,* Tesla Motors,* Bosch,* Nissan,* GM Cruise LLC,* BMW,* Honda, Ford,* Zoox Inc., Drive.ai Inc., Faraday & Future Inc., Baidu USA LLC, Wheego Electric Cars Inc., Valeo North America Inc., NextEV USA Inc., Telenav Inc., NVIDIA Corporation, and AutoX Technologies Inc.

* Companies marked with an asterisk actually did public road testing in California in 2016. The list does not necessarily reflect the level of testing by a particular company. Automakers, tech companies, and suppliers have been testing on public roads in other US states as well as on closed courses.

2.4.1.6. Testing Autonomous Cars: Asia[56]

In Japan, legal initiatives for automated vehicles are on the political agenda but have slowed down significantly. There are private and public test fields, although it was announced that fully automated vehicles cannot be tested on public highways. By the end of 2017, the Japanese manufacturer Toyota and its Lexus division had started offering emergency braking assistants (Toyota Safety Sense or TSS) as standard equipment in virtually all models sold in the United States.

In China, the government has announced that it will develop national regulations for testing autonomous cars on public roads. Cities such as Shanghai and Beijing have designated intelligent-vehicle pilot zones for testing autonomous cars. Baidu, with its open-source Apollo software, is the leader in self-driving car technology in China. In September 2017, Baidu announced its 10 billion yuan ($1.52 billion) Apollo Fund, aimed at investing in 100 autonomous driving projects over the following three years.

In South Korea, the government has been easing legal restrictions on automated driving, and planned to set up public test fields. Hyundai and Kia have positioned themselves very actively in the vehicle-automation segment and have tested prototypes in the United States (Kia Soul and Hyundai Tucson) and in South Korea (Hyundai Genesis).

Singapore has already started working on smart-city mobility concepts. The driverless-car group nuTonomy (in which Bill Ford has invested) offers autonomous taxi services through the Grab ride-hailing platform (which received investment from Honda).

2.4.2. Power-Train Technologies

The automotive industry has continuously increased the efficiency of its power trains by enhancing combustion engines, introducing hybridization (the Toyota Prius in 1997) and (local) emission-free electric vehicles with batteries (the Tesla S in 2012) and, eventually, fuel cells (the Toyota Mirai in 2014). As a result of all these initiatives, average fleet consumption levels

[55] California Department of Motor Vehicles (2016).

[56] Ahrens (2016); Clover, Feng, and Ju (2017); Perper (2017

have come down. At first glance these efficiency improvements seem limited. A look at the VW Golf may serve as an example: in its first generation, it consumed at least 9 liters of gasoline or 6.5 liters of diesel. The current version, the Golf VII, consumes at least 4.9 liters gasoline or 3.8 liters of diesel. To understand the scale of improvement, however, we need to look at the mass of the cars. While the Golf I weighed in at up to 930 kg, the Golf VII has a mass of up to 1,505 kg. So over the past four decades, the mass has increased by 62% while consumption has decreased.

One of the worst developments in this context is the trend toward large passenger cars such as SUVs. The larger the mass of a car, the more it consumes and the higher the emissions will be. Against this background, it is very difficult to understand the decision of Detroit's Big Three automakers (Fiat Chrysler, Ford, and General Motors) to stop manufacturing sedans and to focus on vans and pickups, notably the worst cars to use in terms of consumption and environmental friendliness.

For the foreseeable future, different power trains will coexist, each being more or less suitable for specific uses. Pure battery electric vehicles will appear in urban environments and short-commute scenarios, while plug-in hybrids will be used for mid-size vehicles on regional trips. Gasoline, diesel and alternative energy power trains (such as compressed natural gas) will become more efficient and continue to play a major role for many years, particularly for large passenger cars as well as for commercial vehicles and long-distance travel.

2.4.2.1. Internal Combustion Engines[57]

Thanks to a combination of aerodynamics, lower-rolling resistance tires, weight reduction, and improved engines and transmission systems, new ICE-powered vehicles could see their overall fuel consumption reduced by an additional 30% by 2035 compared to 2012.

Fuel-efficiency and emission standards can be met with diesel engines, particularly CO_2 targets where diesel technology has clear advantages over gasoline. Cars that meet the new Euro 6d-temp standards (obligatory for all new cars in September 2019) or Euro 6d standards (due in 2020 or 2021) meet both CO_2 and NO_x emission targets using the new Worldwide harmonized Light vehicles Test Procedure (WLTP) and Real Driving Emissions (RDE) testing. However, carmakers have admitted that these cars would also be more expensive. Most experts expect diesel engines to disappear from small cars because the costs of diesel exhaust-gas after-treatment systems would make them uncompetitive.[58] As a result of the VW Group's 2015 diesel scandal, several OEMs decided to reduce their lineup of diesel models significantly or discontinue them altogether (as Porsche did).

2.4.2.2. Hybrid Power Trains[59]

Hybrid electric vehicles (HEVs) combine the advantages of internal combustion engines and electric motors. In the city, they can drive in all-electric mode while, on long journeys, they benefit from the combustion engine's range. Hybridization also enables more efficient energy consumption through regenerative braking, dual power sources, and reduced idling. The strengths of plug-in-hybrids compared to electric vehicles come to the fore in larger vehicles

[57] Cheah, Evans, Bandivadekar, and Heywood (2007); Natural Resources Canada (2017); Sims et al. (2014, 613)

[58] See, for example, article on presentation by BMW Group Board Member Klaus Fröhlich: BMW does not see future for Diesel with small cars; Automobil Produktion, January 18th, 2017; https://www.automobil-produktion.de/hersteller/wirtschaft/bmw-diesel-verschwindet-bei-kleinwagen-350.html

[59] Berman (2006)

with mixed operating profiles (long and short distances). Disadvantages include less power, higher prices, more dead weight (such as on freeways when the electric motor is not in use), new maintenance procedures and training, and the problem of battery production and disposal.

The first experiments with hybrid electric power trains date back to the end of the 19th century, with a couple of models and prototypes. Ferdinand Porsche patented the electric wheel-hub motor in 1896, and produced the electric Lohner-Porsche car in 1900. He then equipped the car with an internal-combustion-powered generator to feed the lead batteries, calling it the Lohner-Porsche Mixte. This car had 1.8 tons of batteries and was first shown at the Paris Exhibition in 1900. It was the first hybrid car in automotive history. Several initiatives by different automakers followed, for both passenger vehicles and city buses. However, they did not perform competitively enough against petrol cars, in large part due to low oil prices. Priorities began to change with the oil crisis in the early 1970s, and research into hybrid power trains picked up again. In the 1990s, concern began to grow over the impact of fossil-fuel consumption on climate change. Hybrid electric vehicles first became widely available with the release of the Toyota Prius in Japan in 1997 (a full hybrid, meaning the electric motor can propel the car by itself), followed by the Honda Insight in 1999 (a mild hybrid, meaning the electric motor only supports another fuel source).

More than 11 million hybrid electric vehicles have been sold worldwide since 1997.[60] Japan is the leader in terms of market size, followed by the United States and Europe. Japan is also the leader in terms of penetration, followed by Norway, the Netherlands, France and Sweden. Toyota leads in global sales of hybrid vehicles, followed by Honda, Ford, and Hyundai Motor Group (including Kia). Mercedes-Benz launched 10 new plug-in hybrid vehicles in 2017 (C-Class upward). Hybrid electric vehicles help OEMs achieve their fleet emission targets.

2.4.2.3. Battery Electric Vehicles[61]

In 2015, the milestone of 1 million electric cars on the roads was reached. In 2016, the number passed 1.3 million vehicles. Some 80% of the electric cars on the world's road are located in the United States, China, Japan, the Netherlands and Norway. China's booming sales in 2015 made it the main market worldwide, surpassing the United States. China is also home to the biggest global deployment of electric scooters and buses. BYD, for example, is a leading manufacturer of electric buses and has facilities not just in China but also in Europe and the United States.

Until now, electric vehicles have been a niche product for early adopters. Some challenges for entering the mass market are price and range, compatibility with urban and building infrastructure (charging stations and networks), the disposal of old batteries, distribution and after-sales service.

Some governments offer incentives for EV buyers, while investing in charging infrastructure in urban areas. The effects of these measures are notable in countries such as Norway, the Netherlands, Sweden, Denmark, France, China and the United Kingdom, where the average market share of electric cars rose above 1% in 2015. (The market shared reached 23% in Norway and nearly 10% in the Netherlands.)

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[60] Source: Totota; https://pressroom.toyota.com/releases/toyota+10+million+global+hybrid+sales.htm

[61] Kasten, Bracker, Haller, and Purwanto (2016).

Manufacturers are focusing on improving battery technology to maximize range and minimize weight, with the objective of pushing cost below the threshold of $100 per kilowatt-hour, at which a battery-powered car would become competitive with traditional cars.

In discussions about battery electric vehicles, little attention is paid to the emissions generated during the manufacture and disposal of the batteries. It remains to be seen whether politicians will start to take a closer look at these issues, as the verdict about BEVs might change. A 2010 study published by the Argonne National Laboratory in Illinois, looking at cradle-to-gate emissions, concluded that, during the manufacture of a 1 kg Li-ion battery, some 14.5g of NO_x on average are released into the atmosphere (Sullivan and Gaines 2010). To put this in context: the production of a 100 kWh battery pack, weighing about 800 kg and used in the cars of a California-based OEM of BEVs, would therefore release some 11.6 kg of NO_x into the atmosphere. Modern diesel cars meeting Euro 6 standards would need to drive some 116,000 km before reaching this level. For gasoline-powered cars, it would be an even longer distance.

The disposal of batteries is another critical issue. Current battery technology generates highly hazardous and toxic waste. EV manufacturers are therefore looking into second-life user scenarios for the batteries coming out of cars when they reach the 80% capacity threshold. Most such scenarios envision batteries being used for energy storage in urban or office environments, supporting the development of smart-grid technology. Until proper infrastructure is in place there are few alternatives. Even under this scenario, eventually these large batteries have to be disposed of. (The battery pack of a Tesla Model S P100D, for example, weighs close to a ton.) Battery waste includes heavy metals such as cobalt and nickel, but also toxic residues. China, the leading EV country, expects to have around 170,000 tons of battery waste in 2018 and for the figure to grow as the penetration rate of EVs increases.[62] In 2017, around 80 million passenger cars were produced. If 10% of these were BEVs using advanced battery technology such as that of a Tesla Model 3 (with a battery pack weighing in at 1,065 lb or 483 kg), this would represent around 4 million tons of batteries per year. Eventually these batteries would need to be recycled, a problem that will receive increasing attention as BEVs gain a greater share in our mobility mix.

2.4.2.4. Fuel-Cell Electric Vehicles[63]

Fuel cells were invented in 1839 by the Welsh judge Sir William Robert Grove.[64] The first commercial use of fuel cells came more than a century later during NASA space programs to generate power for satellites and space capsules.

Unlike battery electric vehicles, fuel-cell electric vehicles (FCEVs) generate the electricity to power the motor using oxygen from the air and hydrogen. FCEVs are classified as zero-emission vehicles because they emit only water and heat. They differ from BEVs not only in the source of electricity but also in the time required to recharge or refuel, the driving range, and the ability to scale up the size of the vehicle.

Hydrogen can be produced using several different processes. Thermochemical processes are the most widely used today and use heat and chemical reactions to release hydrogen from organic materials such as fossil fuels and biomass. This method does release greenhouse gases. Cleaner alternative processes—such as splitting water (H_2O) into H_2 and O_2 through electrolysis or solar

[62] David Stanway, "China's Recyclers Eye Looming Electric Vehicle Battery Mountain," Reuters, October 23, 2017, https://www.reuters.com/article/us-china-batteries-recycling-insight/chinas-recyclers-eye-looming-electric-vehicle-battery-mountain-idUSKBN1CR0Y8.

[63] H2USA (2017); HyFIVE (2017).

[64] Source: http://www.fuelcelltoday.com/history

energy or producing H_2 by means of bacteria—are in the early stages of research but offer long-term potential for sustainable hydrogen production with a low environmental impact. Other challenges include affordability and distribution.

Manufacturers have been cooperating on fuel-cell technology research and development. BMW is collaborating with Toyota, and Honda with General Motors. Daimler, Hyundai, Nissan, Ford and the PSA Group are also working on the technology, although at different speeds. Audi has taken on the lead function as the Volkswagen Group's "center of excellence" for fuel cells. Although Fiat Chrysler sees FCEVs as a more promising technology than BEVs, the company believes the technology belongs to a distant future.

The London-based project HyFIVE (Hydrogen for Innovative Vehicles) is one of several efforts to promote the adoption of fuel-cell vehicles in Europe. It will deploy 185 hydrogen-powered vehicles to private and corporate customers in Austria, Denmark, Germany, Italy, Sweden and the United Kingdom. Participating automakers that will produce fuel-cell cars include BMW, Daimler, Honda, Hyundai and Toyota.

As of mid-2016, there were 80 hydrogen stations operating in Japan, where the government is keen to boost the number of such facilities considerably before the 2020 Summer Olympics in Tokyo.

The need for a hydrogen-fueling infrastructure in the United States is being addressed by H_2USA and the Hydrogen and Fuel Cells Program Plan, among other initiatives supported by the US Department of Energy.

2.5. Environmental Factors[65]

Air pollutants from vehicles can be divided into greenhouse gases (such as CO_2, N_2O and CH_4) and local air-quality pollutants (such as NO_x and particulate matter or PM). When it comes to the control of greenhouse gas emissions, the EU has stricter standards than the United States, but US targets are more ambitious for local air pollutants. Considering that the US passenger-car fleet is 50% more powerful, 14% heavier, and 5% larger than the EU fleet, meeting similar emission-reduction targets is more challenging for the United States.

2.5.1. CO_2 Emissions in the Automotive Sector[66]

The transport sector is responsible for 14% of global CO_2 emissions, and car are responsible for 45% of that amount. This means that more than 6% of global CO_2 emissions come from automobiles. To help mitigate the negative effects on the environment and improve the energy performance of vehicles and fuels, since the early 1980s, many governments have been developing and implementing regulations and other transport-sector policies. Fuel-economy standards have evolved significantly in recent years. As of February 2018, 10 out of the top 15 global vehicle markets had adopted fuel-economy standards for passenger vehicles: China, the European Union, the United States, Japan, Brazil, India, Canada, South Korea, Mexico, and Saudi Arabia. By the end of 2015, about 80% of new passenger-car sales were subject to GHG emission and fuel-economy standards.

The following sections present the main CO_2 emission regulations by region.

[65] Yang and Bandivadekar (2017).

[66] Sources: Miller and Façanha (2014); Straube (2011).

2.5.2. CO_2 Emission Standards by Region[67]

2.5.2.1 European Union

Light-Duty Vehicles

The European Union began implementing programs to reduce CO_2 emissions in the mid-1990s. At first, the targets were voluntary for manufacturers. Since 2009, the European Commission (EC) has imposed emission-control requirements on vehicles sold in all EU member states. Regulation (EC) No 443/2009 set an average CO_2 emission target for new passenger cars of 130 g/km. The target was phased in gradually between 2012 and 2015. A target of 95 g of CO_2 per kilometer will apply from 2021.

The current level of exhaust-emission standards for cars and light-duty trucks, Euro 6, became effective in 2015 for new vehicle registrations. The regulatory requirements include random testing of newly assembled vehicles and a manufacturer in-use surveillance program. However, from a technical perspective, EU emission standards do not reflect everyday usage. So EU emission standards were to focus particularly on further reducing emissions from diesel vehicles by introducing new testing criteria based on "real-world driving" emissions (RDE). RDE tests became effective in 2017.

Additional technologies will increase the cost of diesel engines, which are already higher than gasoline engines. This puts additional pressures on the already challenging EU market for small and mid-size diesel vehicles. Gasoline engines are also affected by the new requirements, and the measures to reduce emissions have a negative effect on the engine's fuel economy, leading to additional technology costs to maintain fuel economy.

Heavy-Duty Vehicles

Unlike for passenger cars, the standards for heavy-duty vehicles (trucks and buses) are defined by engine energy output (g/kWh) and not for driving distance (g/km). The current standard for heavy-duty vehicles is Euro VI, in place since 2013 and updated in 2017 to Euro 6c, to be followed by Euro 6d.

2.5.2.2. United States[68]

Light-Duty Vehicles

The United States has been regulating fuel economy for light-duty vehicles since 1975, when the Corporate Average Fuel Economy (CAFE) standards were established. However, it was not until 2009 that fuel-economy standards were set at the federal level and included greenhouse gas (GHG) emission limits. Since 2009, fuel-economy and GHG standards have been set jointly by the National Highway Traffic and Safety Administration (NHTSA) and the Environmental Protection Agency (EPA) at the federal level, in different so-called "tier" categories. California is the only state that has been granted authority to set its own CO_2 standards, the Low-Emission Vehicle (LEV) regulations.

New vehicle fleets in the United States have to comply with the tier standards, which consist of a set of different limits for different vehicle categories. (Individual values are sales-weighted to

[67] International Council on Clean Transportation (2017); Nesbit et al. (2016).

[68] International Council on Clean Transportation (2017); Nesbit et al. (2016).

calculate fleet-average emissions.) Manufacturers are given a phase-in period within which they are legally required to ensure that an increasing proportion of their new vehicles and engines meet the relevant standards. Older vehicles must continue to meet the preceding regulations under which they were certified.

Tier standards progressively became more stringent over time and included heavier vehicle categories. Tier 3 standards, implemented in 2017, are now in line with the California LEV III standards to achieve consistency at a national level. Tier 3 standards cover all new vehicles that come into the Tier 1 and Tier 2 categories as well as all heavy-duty vehicles with a gross vehicle weight rating (GVWR) of less than 14,000 lb (6,350 kg).

Unlike EU standards, US Tier 3 and California LEV III standards are fuel-neutral in that they have the same limits for gasoline and diesel. Light trucks and commercial vehicles have different, less stringent standards. Light trucks are defined as vehicles with a gross weight of up to 3.85 tons and include pickups, SUVs and vans. These are the best-selling vehicle categories in the United States. (The Ford F-150 pickup has topped the list of best-selling vehicles for years, at close to 1 million units per year in the United States alone.)

2.5.2.3. China[69]

Light-Duty Vehicles

China started regulating fuel consumption for passenger vehicles in 2004, when the government established Phase I standards to be phased in during 2005 and 2006. Following the success of Phase I, Phase II standards were established, and phased in during 2008 and 2009.

In 2009, China announced the development of Phase III of its fuel-consumption regulation program, to be phased in from 2012 to 2015. The Phase III standards set a fleet average fuel consumption for new vehicles of 6.9 liters per 100 km by 2015. (This was equivalent to 161 g/km of CO_2 according to International Council on Clean Transportation or ICCT conversion methodology.) In December 2014, Phase IV was announced, to take effect starting in 2016. These standards set a fleet average target of 5.0 liters per 100 km for new vehicles sold in 2020. (This is equivalent to 117 g/km of CO_2 according to ICCT conversion methodology.)

Heavy-Duty Vehicles

In 2011, the Ministry of Industry and Information Technology (MIIT) adopted an industry standard to regulate the fuel consumption of heavy-duty diesel and gasoline vehicles with a gross vehicle weight of more than 3.5 tons. The standard was updated in 2012, setting an estimated fleet average fuel reduction of 11% by 2015. The industry standard (now called MIIT National Standard) covers three vehicle categories: tractors, cargo trucks (not including dump trucks) and buses/coaches (not including city buses).

[69] International Council on Clean Transportation (2015); TransportPolicy.net (2015).

2.5.2.4. Japan[70]

Light-Duty Vehicles

Japan has traditionally had the most fuel-efficient vehicle fleet in the world. Japan's fuel economy standards have always been rigorous in comparison to those of other countries. However, the 2020 targets show that the latest Japan's CO_2 standards are less stringent than those set in the EU and United States (TransportPolicy.net, Japan's Light Duty Vehicles).

One program that was central to Japan's success in reducing emissions is the Top Runner Program, introduced by the government in 1999. The initiative consists of an energy-efficiency system. It identifies the most fuel-efficient automobile in each weight class and designates it the "top runner." Fuel-consumption targets are then set at the level of the top runner. The effectiveness of the standards is enhanced by financial incentives—such as progressive taxes levied on the vehicle weight and engine displacement—that promote the purchase of lighter vehicles.

Japan's latest CO_2 emission standards for passenger cars were established in 2011, when the Japanese government set a fuel-economy target of 20.3 km per liter by 2020. (This is equivalent to 122 g of CO_2 per kilometer according to ICCT conversion methodology.)

Heavy-Duty Vehicles

In November 2005, the Japanese government introduced its first fuel-economy standards for new heavy-duty diesel vehicles. Those standards, affecting commercial trucks with a gross vehicle weight in excess of 3.5 tons and buses with a carrying capacity above 11 people were incorporated into Japan's broad Top Runner system for energy efficiency. Despite it being the first country to introduce regulations for heavy-duty vehicles, Japan's CO_2 standards did not take full effect until 2015.

2.5.3. CO_2 Emission Status by Region

The EU's CO_2 reduction targets for transport involve a cap of 95 g of CO_2 per kilometer by 2020 (effective by 2021)[71]. The targets are ambitious compared to those of the United States (93 g/km by 2025), China (117 g/km by 2020) and Japan (105 g/km by 2020). Furthermore, the regulations are likely to tighten further after 2021.

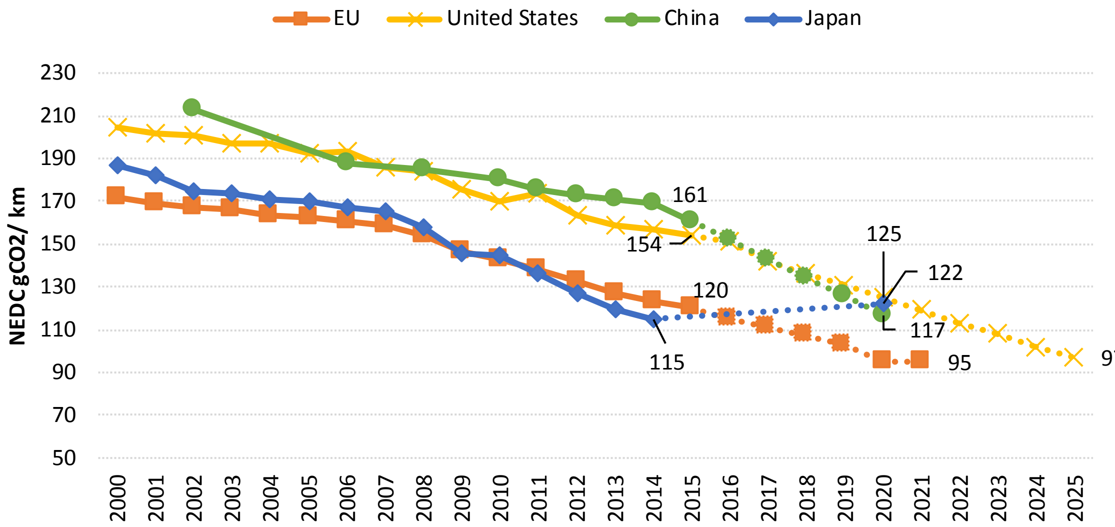
Figure 198 compares the historical performance and enacted targets for CO_2 emissions in passenger cars by country, in terms of New European Driving Cycle (NEDC) gCO_2/km.

[70] International Council on Clean Transportation (2015); TransportPolicy.net (2015).

[71] https://ec.europa.eu/clima/policies/transport/vehicles/cars_en

Figure 199

Evolution of CO2 Emissions in Passenger Cars by Country (NEDC gCO2/km)



Note: China's target reflects gasoline vehicles only. The target may be higher after new-energy vehicles are considered. US standards on GHG emissions are set by the EPA, and these differ slightly from fuel-economy standards due to low-GWP (global warming potential) refrigerant credits.

Source: https://www.theicct.org/sites/default/files/publications/ICCT_CO2-newPVs-2015_201606.pdf; p. 12.

Japan reached its 2022 target of 122 g/km in 2013. If Japan continues to reduce emissions at the same rate, its passenger-vehicle fleet would achieve 82 g/km in 2020, far below the targets set by other countries.

Table 23

CO_2 Emission Status and Targets by Region (NEDC gCO_2/km)

	EU		United States		China		Japan	
	Cars	LCV	Cars	LT	Cars	LCV	Cars	LT
2000	172		205	279			187	
2001	169		202	284			182	
2002	167		201	277	213		175	
2003	166		197	272			174	
2004	163		197	276			171	171
2005	162		192	268			170	
2006	161		193	263	188		167	
2007	159		186	256			165	
2008	154		184	250	185		158	
2009	147	185	176	237			146	
2010	143	180	170	233	180	206	145	
2011	138	179	174	238	176	207	136	
2012	133	178	163	235	173	202	127	164
2013	127	175	159	230	171	**198**	119	
2014	123	169	157	222	169	**193**	115	
2015	**120**	**168**	**154**	**213**	**161**	**189**		**155**
2016	**115**	**164**	**151**	**202**	**152**	**184**		
2017	**111**	**159**	**142**	**198**	**143**	**1180**		
2018	**107**	**155**	**136**	**194**	**134**	**175**		
2019	**103**	**151**	**131**	**190**	**126**	**171**		
2020	**95**	**147**	**125**	**186**	**117**	**166**	**122**	
2021	**95**		**119**	**173**				
2022			**113**	**165**				**135**
2023			**108**	**156**				
2024			**102**	**148**				
2025			**97**	**141**				

Source: International Council on Clean Transportation, https://www.theicct.org/sites/default/files/publications/2017-Global-LDV-Standards-Update_ICCT-Report_23062017_vF.pdf.

Notes: Black = historical performance
Red = enacted target
LCV = light commercial vehicle
LDV = light-duty vehicle
LT = light truck
NEDC = New European Driving Cycle

2.5.4. CO_2 Emission Status by Manufacturer in the European Union

Based on provisional data released by the European Environment Agency (EEA), all manufacturers in the European Union achieved their 2015 targets of 130 g of CO_2 per kilometer ahead of time, with average emissions of 123.3 g/km in 2014.

The individual targets vary among manufacturers, depending on the average weight of their vehicle fleets.

Table 24
CO_2 Emissions by Manufacturer in the European Union

2016	EU market share	Average mass (kg)	CO_2 (g/km)		Remaining reduction to target
			2016 without supercredits	2020/21 target	
PSA	17%	1281	110	91	21%
Fiat	6%	1247	120	90	33%
Renault-Nissan	15%	1304	111	92	21%
Toyota	4%	1340	105	93	13%
Ford	7%	1369	120	94	28%
Average*		1388	118	95	24%
Volkswagen	24%	1419	120	96	25%
BMW	7%	1572	123	101	22%
Daimler	6%	1584	125	102	23%

* Average values include also manufacturer groups with smaller market shares not shown independently in the table.

Source: International Council on Clean Transportation (June 2017, based on EEA data).

Despite being close to the EU target in 2016, key manufacturers still needed to improve their emissions standards drastically to achieve the 2020/21 target. Further reduction requirements ranged from 13% (Toyota) to 33% (Fiat). On average, key manufacturers needed to reduce their emissions by 24% in five years.

2.5.5. Key Vehicle Parameters

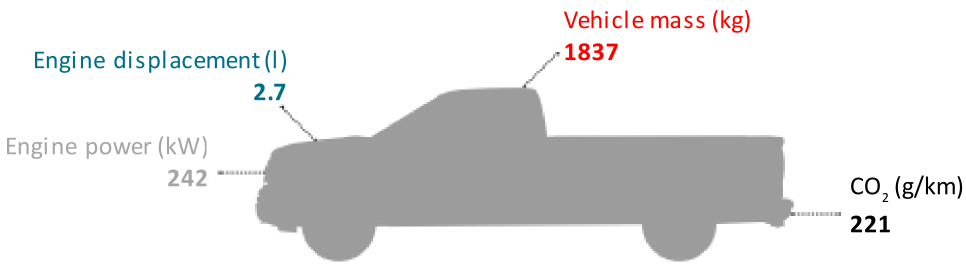
The average weight of new vehicles in the EU increased in 2016, to 1,392 kg. It increased 10% in the previous 15 years. The heaviest car fleets in the EU in 2016 were in Germany (1,562 kg) and Sweden (also 1,562 kg). In contrast, the Dutch opted for the lightest vehicles, with an average weight of 1,303 kg.

Engine power increased by 30% in the 15 years up to 2016, achieving 95 kW. Over the same period, the average engine displacement was reduced by 7%, and the average number of cylinders decreased as well. This was partly due to the economic crisis but mainly reflected a technological trend. Improved combustion processes and turbocharging allowed manufacturers to extract more power from smaller engines. Thus, manufacturers could replace a six-cylinder engine with a four-cylinder one and generally reduce engine displacement (International Council on Clean Transportation 2017).

Below are the top-selling vehicles in selected countries and the EU with their engine power, engine displacement, vehicle mass, and CO_2 emissions.

2.5.5.1. United States

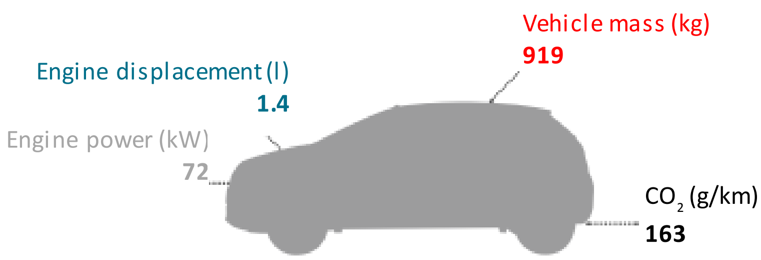
Ford F-150 (gasoline)



Source: International Council on Clean Transportation (2017).

2.5.5.2. Brazil

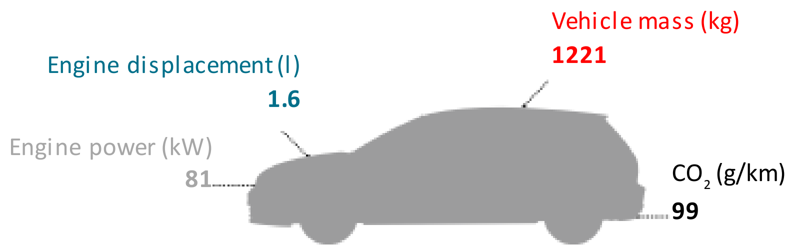
Chevrolet Onix (gasoline and ethanol flexible fuel)



Source: International Council on Clean Transportation (2017).

2.5.5.3. European Union

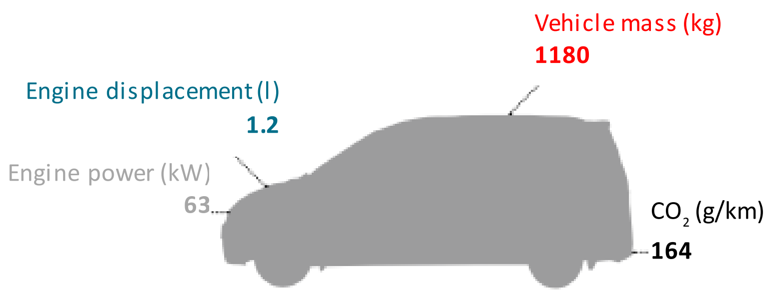
Volkswagen Golf (diesel)



Source: International Council on Clean Transportation (2017).

2.5.5.4. China

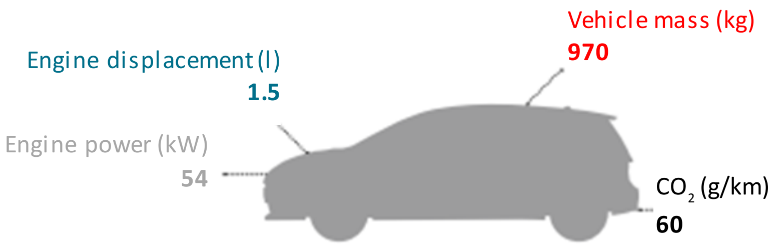
Wuling Hongguang (gasoline)



Source: International Council on Clean Transportation (2017).

2.5.5.5. Japan

Toyota Aqua (gasoline-electric hybrid)



Source: International Council on Clean Transportation (2017).

2.5.6. NO_x Emissions in the Automotive Sector

NO_x forms when nitrogen reacts with O_2 at elevated temperatures inside the engine. Over the 15 years from 2001 to 2016, NO_x limits for diesel car engines were reduced by 84%.

Diesel engines consume 20% to 25% less fuel than equivalent gasoline engines and thus have longer ranges and greater power. They produce 15% less CO_2 emissions per kilometer than equivalent petrol engines (CleanDieselTech, 2015). However, diesel engines operate at much higher cylinder pressures, which lead to high in-cylinder temperatures, generating high NO_x emissions. This process is even more pronounced with turbocharged diesel engines, which increase the O_2 in the combustion process (the same applies to turbocharged gasoline engines) and also increase the amount of time the combustion mix remains in the chamber (less time leads to more NO_x).

To keep pace with CO_2 emission goals, automakers have spent years reducing the size of their engines. The heat from a smaller engine's turbo, however, generates more NO_x. Paradoxically, the reducted in CO_2 emissions led to higher NO_x emissions. However, because emission tests were not run under real-world driving conditions, the small turbocharged diesel engines performed well in government emission and efficiency tests. Discrepancies between laboratory and on-road testing were first put on the table by the Environmental Research Group at King's College London in 2011 but these did not get much attention until the diesel scandal involving Volkswagen broke in September 2015.

The following sections discuss NO_x regulations and emissions relating to passenger cars in the European Union and the United States. It is important to note that the penetration of diesel cars in the EU is 53%, while in the US they represent less than 1% of the fleet (Nesbit et al. 2016).

2.5.6.1. European Union

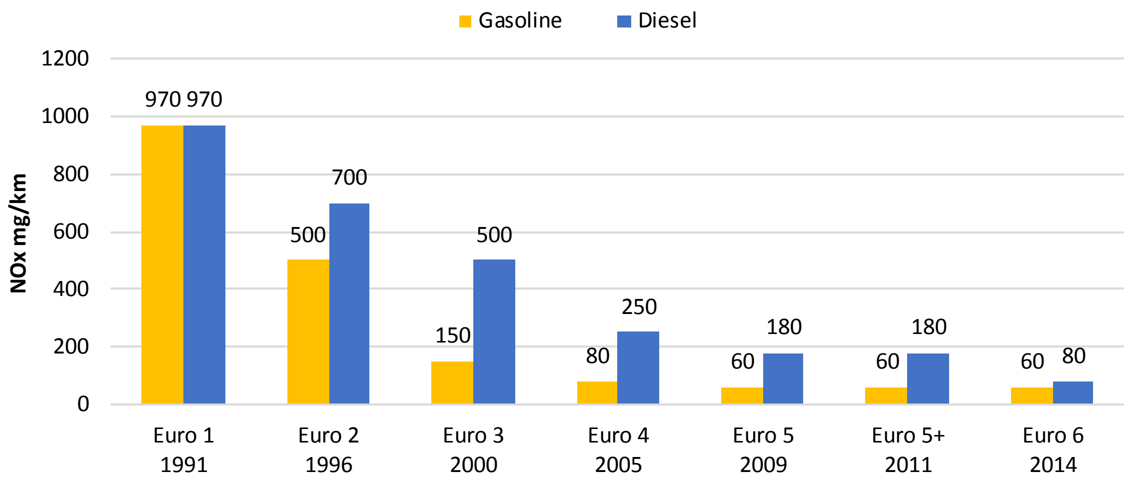
Between 2001 and 2016, EU emission legislation progressively reduced the amount of NO_x that a vehicle was allowed to emit. These emissions standards, commonly referred to as "Euro" classes, include other pollutants such as carbon monoxide (CO), hydrocarbons (HC) such as nonmethane hydrocarbons (NMHC), and PM and particle number (PN) emissions. Euro 0 to Euro

6 refer to light-duty vehicles, whereas Euro 0 to Euro VI (with Roman numerals) refer to heavy-duty vehicles.

The standards for NO_x also differ according to the vehicle's fuel type. The following graph summarizes the NO_x standards for gasoline and diesel passenger cars since the introduction of Euro 1.

Figure 200

NO_x Emission Standards in the EU (for New Vehicles)



Source: International Council on Clean Transportation (2017).

2.5.6.2. United States

The United States has historically had the world's most stringent vehicle tailpipe conventional pollutant emission standards. The first nationwide US light-duty vehicle emission standards were implemented in 1968, and subsequently reviewed every couple of years[72].

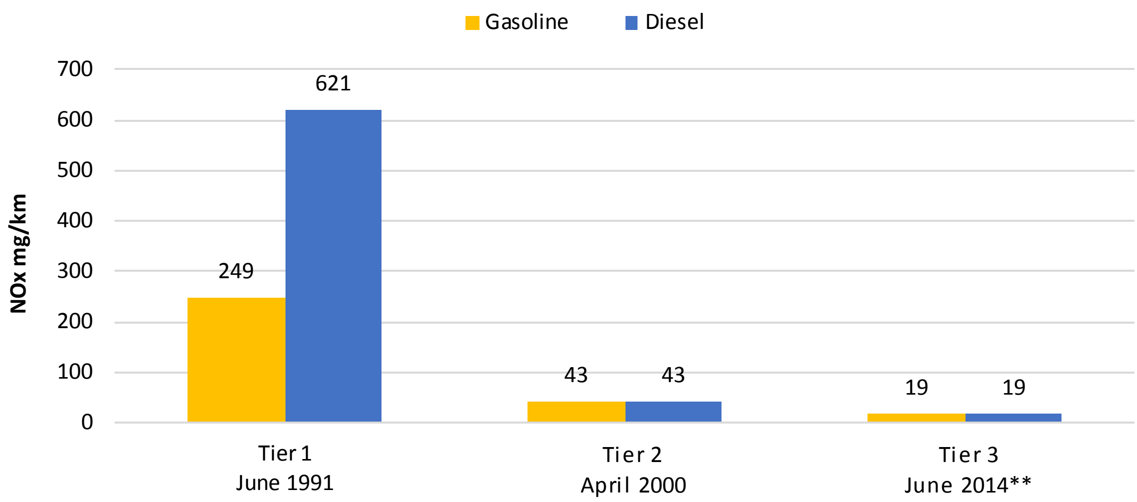
NO_x emissions standards in the United States are regulated by the so-called tier programs.

In the Tier 1 program, diesel and gasoline passenger cars were treated differently. However, since the introduction of Tier 2, cars, light-duty trucks, and medium-duty passenger vehicles (MDPVs) are subject to the same standards. (Only heavy-duty vehicles are treated differently.) Moreover, since the Tier 2 program began, US legislation has applied the same emission limits for all types of vehicle fuel, making no distinction between diesel and gasoline. This is in clear contrast with EU emission legislation.

[72] TransportPolicy.net, "US: Light-Duty: Emissions," https://www.transportpolicy.net/standard/us-light-duty-emissions/

Figure 201

NO_x Emission Standards in the United States*



* For new vehicles. US Tier 2 and 3 standards are fleet average standards, whereas Euro 6 is based on maximum limits. The US Tier 2 phase lasted from 2004 to 2009, and Tier 3 phase covers 2017 to 2025.
** Tier 1 and 2 are NO_x standards. Tier 3 considers values of nonmethane organic gases (NMOG) as well as NO_x and has a 2025 target.

Source: TransportPolicy.net, "US: Light-Duty: Emissions," 2015, https://www.transportpolicy.net/standard/us-light-duty-emissions/.

2.6. Legal Factors

2.6.1. Regulatory Bodies in Europe

The main authorities regulating environmental standards for the automotive industry in Europe are:

- European Union: The EU defines directives for emission standards in the EU member states and European Economic Area member states, staging the progressive introduction of increasingly stringent standards.
- European Commission: The EC formulates and implements policies for the EU to meet its climate targets for 2020, 2030 and beyond.
    - Horizon 2020: Under the research program Horizon 2020, €6.4 billion is available for low-carbon mobility projects.
- European Environment Agency: The agency, in its own words, "provides sound, independent information on the environment for those involved in developing, adopting, implementing and evaluating environmental policy, and also the general public."

Compliance with standards is verified by running the engine at a standardized test cycle. New models must meet current or planned standards. Vehicles that do not pass the test cannot be sold in the EU but the new standards do not apply to vehicles already on the roads.

2.6.2. Regulatory Bodies in the United States

The main authorities regulating environmental standards for the automotive industry in the United States are:

- **National Highway Traffic Safety Administration:** The NHTSA develops the Corporate Average Fuel Economy (CAFE) standards for automotive fuel efficiency. These were first enacted by the United States Congress in 1975 after the Arab oil embargo of 1973–74. "The CAFE achieved by a given fleet of vehicles in a given model year is the production-weighted harmonic mean fuel economy, expressed in miles per US gallon (mpg), of a manufacturer's fleet of current model year passenger cars or light trucks […], produced for sale in the United States" [73]
Website: https://www.nhtsa.gov/.
- **US Environmental Protection Agency (EPA)**
Website: https://www.epa.gov/.
- **California Air Resources Board (CARB)**
Website: https://www.arb.ca.gov/.

The three regulatory authorities upgraded the CAFE standards in 2012 to increase fuel-efficiency goals to 54.5 miles per gallon (23.2 km per liter) or 163 g of CO_2 per mile by 2025.

A few basic adjustments will affect what the 2025 standards will really mean for consumers: special credits, real-world values, and varying standards by vehicle type.

Automakers can earn special credits, for example by using improved air-conditioning technologies (with low-global-warming refrigerants) or by producing plug-in electric and hybrid vehicles. Those measures do not directly increase fuel economy under the standard city-highway regulatory test but provide greater incentives for the development of nascent technologies.

Moreover, the real-world fuel economy has historically been 20% lower than the official regulatory test procedure used for automaker compliance. This 20% difference between the official CAFE number and the actual number of miles per gallon is caused by factors such as drivers' aggressive acceleration, idling time, high speeds on the highway, and accessory use.

Each automaker is subject to varying standards based on its sales-weighted average vehicle size and its mix of vehicle types. By design, all vehicle types are pushed to improve their efficiency by about the same percentage. In practice, this means that manufacturers making larger vehicles, such as General Motors, Ford, and Chrysler in the United States, will get less stringent absolute standards. Consequently, the rules push all automakers to improve their technology but not to make smaller vehicles. These provisions were regarded as necessary to achieve industry buy-in.

[73] Wikipedia, "Corporate Average Fuel Economy," https://en.wikipedia.org/wiki/Corporate_average_fuel_economy

2.6.3. Test Cycles

An emission test cycle is a protocol that enables the repeatable and comparable measurement of exhaust emissions for different engines or vehicles. Test cycles specify conditions under which the engine or vehicle should be operated during the emission test. Specified parameters in a test cycle include a range of operating temperature, speed, and load. Each government and working group usually has its own test cycle, which makes it hard to compare the different regulations and vehicle performances in different countries.

Ideally, the test cycle is defined so as to represent accurately and realistically the range of conditions under which the vehicle or engine will be operated in actual use. However, such a general outcome is very unrealistic.

Vehicle and engine manufacturers can exploit this limitation by programming their engine-management systems to control emissions so they stay within regulation levels at the specific test points in the cycle. Vehicles may comply with the specific standards in test conditions but still create a lot of pollution in real-world conditions. This results in real emissions that are higher than the standards are supposed to allow, undermining the effect of regulations on public health and the environment.

Current driving cycles:

- Europe:
  New European Driving Cycle (NEDC), also referred to as the MVEG cycle (after the Motor Vehicle Emissions Group): ECE R15 (1970)/Extra-Urban Driving Cycle (EUDC, 1990)
- United States:
  EPA Federal Test: Federal Test Procedure (FTP) 72/75 (1978)/Supplemental Federal Test Procedure (SFTP) US06/SC03 (2008)
- Japan:
  10 Mode/10-15 Mode (1983)/Japan Cycle ’08 (JC08, 2008)
- Global harmonized:
  Worldwide harmonized Light vehicles Test Procedure (WLTP, 2015), now also adopted by EU countries

2.6.4. Laboratory Versus On-Road Tests of NO_x[74]

In September 2015, the US Environmental Protection Agency found that many Volkswagen diesel passenger cars being sold in the United States had a “defeat device” that could detect when they were being tested, changing their performance accordingly to improve lab results. The report that brought the issue to light was actually published in May 2014 (Thompson et al. 2014). However, at that time, when the results of the study became known, the EPA ordered Volkswagen to investigate and fix the problem, and the company claimed that it had done so.

The report from West Virginia University’s Center for Alternative Fuels, Engines and Emissions studied emissions from three diesel cars under a variety of driving conditions. The car models were kept anonymous in the paper but it was subsequently revealed that “Vehicle A” was a 2012 VW Jetta, “Vehicle B” was a 2013 VW Passat, and “Vehicle C” was a BMW X5. In their report, the

[74] Carslaw et al. (2011); Thompson et al. (2014).

West Virginia researchers point out the conflicting road-lab NO_x results for VW diesel cars. While both the Jetta and the Passat had passed the lab tests successfully, their NO_x emissions on the road were much higher. NO_x emissions for the Jetta were 15 to 35 times higher than the EPA standards, and those for the Passat were 5 to 20 times higher.

The West Virginia report was not the first to pose this problem. Discrepancies between laboratory and on-road testing were first put on the table by David Carslaw of the Environmental Research Group at King's College London in 2011. Carslaw et al. (2011) studied vehicle-emission remote-sensing data from a sample of 84,269 vehicles in seven urban locations across the United Kingdom between 1985 and 2010. The authors found significant discrepancies between UK/European estimates of NO_x emissions and those derived from the remote-sensing data for several important brands and classes of vehicles, mainly diesel cars.

In the case of gasoline cars, the remote-sensing data showed that NO_x emissions from recent model cars (2005–10) were substantially lower than those of early-model cars. In particular, the authors show that there is a step change in NO_x emissions from 1992 to 1993, which corresponds to the introduction of three-way catalysts on gasoline cars in the United Kingdom. This suggests that the three-way catalyst was quite effective for controlling emissions of NO_x in gasoline cars.

For diesel cars, however, NO_x emissions tended to increase over the period from 1987 to 2010. Moreover, the authors find that absolute emissions of NO_x in diesel cars are higher across all legislative classes and brands than those suggested by UK and other European emission inventories.

The explanation lies in the turbocharging technology. The increasingly stringent emission legislation on CO_2 has pushed many car manufacturers to reduce the size of their engines to meet the lower CO_2 limits. The turbocharging technology allows the engine power to be increased without augmenting the engine size. As a result, almost all diesel cars following Euro 3 to 5 standards use turbocharging technology, leading to higher NO_x emissions. In sum, the augmented engine power derived from the turbocharging technology has led NO_x/CO_2 ratios in diesel cars to increase markedly since its introduction.

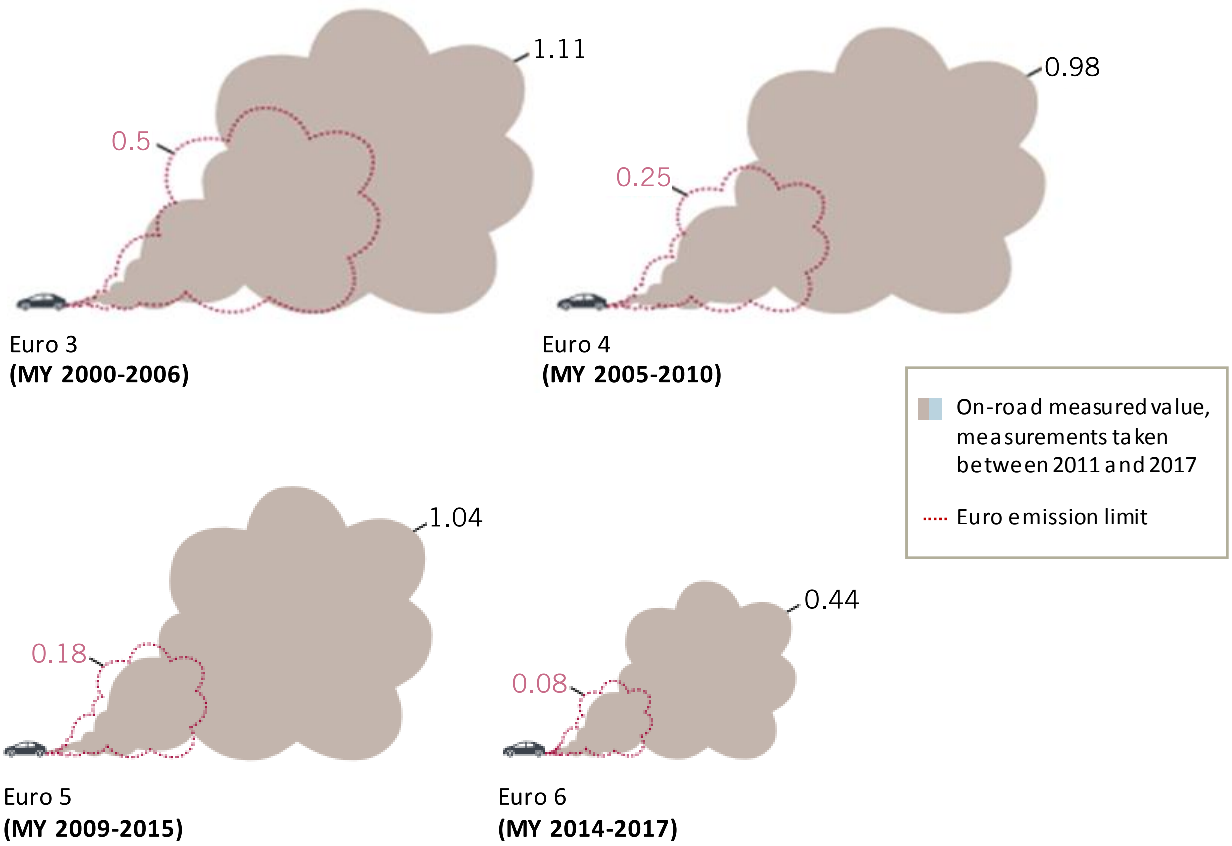
Table 25

NOx Emissions (g/km) for Diesel Passenger Cars

		Euro emission limit	On-road measured value
Euro 3	2000	0.50	1.11
Euro 4	2005	0.25	0.98
Euro 5	2009–15	0.18	1.04
Euro 6	2014–17	0.08	0.44

Source: International Council on Clean Transportation (2018). Values from CONOX database/IVL.

Figure 202



Source: International Council on Clean Transportation (2018, 67).

3. Manufacturer Information

3.1. Global presence of Top 10 Manufacturers

Table 26

Number of Manufacturers' Vehicle and Parts Production Facilities in Each Country and Region as of 2016

	FCA	Ford	GM	Honda	Hyundai	Kia	Nissan	PSA	Renault	Toyota	VW	Grand total
North America	22	28	41	15	1	1	5			11	1	125
Canada	3	3	4	3						2		15
United States	19	25	37	12	1	1	5			9	1	110
Mexico	5	3	5	3			4			1	3	24
South America	5	3	6	8	1		2	3	4	3	9	44
Argentina	1		1	2				2	1	1	3	11
Brazil	3	2	3	5	1		2	1	1	1	6	25
Chile									1			1
Colombia			1						1			2
Ecuador			1									1
Peru				1								1
Venezuela	1	1								1		3
EU	9	12	11	4	1	1	2	28	20	5	63	156
Austria			1					1			1	3
Belgium											1	1
Czech Republic						1			1		1	4
Denmark											2	2
France	1	2	2	1				20	13	1	3	43
Germany		6	3								29	38
Hungary			2								1	3
Italy	7			2				1			2	12
Netherlands								1			2	3
Poland	1		1							2	8	12
Portugal								1	1	1	1	4
Romania		1							1			2
Slovakia		1				1		1			2	5
Slovenia									1			1
Spain		2	2	1			2	2	4		4	17
Sweden											3	3
Other Europe	2	6	2	2	1		1	2	1	2	6	25
Bosnia-Herzegovina												1
Switzerland											2	2
Turkey	1	2		1	1			2	1	1	1	10
UK		4	2	1			1			1	1	10
Finland											1	1
Serbia	1											1

Table 26 (continued)

	FCA	Ford	GM	Honda	Hyundai	Kia	Nissan	PSA	Renault	Toyota	VW	Grand total
Asia	3	16	21	38	10	4	22	4	4	33	29	184
Bangladesh				1						1		2
China (mainland)	1	6	11	15	3	1	6	2	1	9	18	73
India	1	2	2	6	2		1		1	2	6	23
Japan	1	2	4	12			12	1		17		49
Kazakhstan										1		1
Pakistan				3						1		4
Russia		4	1		1		2	1	1	1	3	14
South Korea			3		4	3			1		1	12
Taiwan		2		1			1			1	1	6
Southeast Asia and Oceania	1	3	2	29		1	8	2		12	3	61
Australia				1			1			1		3
Indonesia				9			1			4		14
Malaysia				6			2	1		1	1	11
Philippines				3			2			2		7
Thailand	1	2	1	5			1			3	2	15
Vietnam		1	1	5		1	1	1		1		11
Africa and Middle East		2	2	3			2	3	3	3	4	22
Algeria									1			1
Egypt			1				1			1		3
Iran								1				1
Kenya				1				1		1		3
Morocco									2			2
Nigeria				2				1				3
South Africa		2	1				1			1	4	9
Grand total	**47**	**73**	**90**	**102**	**14**	**7**	**46**	**42**	**32**	**70**	**118**	**641**

Source: Manufacturers' corporate websites and annual reports, 2017.

Table 27
How Each Manufacturer Distributes Its Facilities by Region

	FCA	Ford	GM	Honda	Hyundai	Kia	Nissan	PSA	Renault	Toyota	VW	Grand total
North America	47%	38%	46%	15%	7%	14%	11%	0%	0%	16%	1%	20%
Mexico	11%	4%	6%	3%	0%	0%	9%	0%	0%	1%	3%	4%
South America	11%	4%	7%	8%	7%	0%	4%	7%	13%	4%	8%	7%
EU	19%	16%	12%	4%	7%	14%	4%	67%	63%	7%	53%	24%
Other Europe	4%	8%	2%	2%	7%	0%	2%	5%	3%	3%	5%	4%
Asia	6%	22%	23%	37%	71%	57%	48%	10%	13%	47%	25%	29%
Southeast Asia and Oceania	2%	4%	2%	28%	0%	14%	17%	5%	0%	17%	3%	10%
Africa and Middle East	0%	3%	2%	3%	0%	0%	4%	7%	9%	4%	3%	3%
Grand total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Manufacturers' corporate websites and annual reports, 2017.

Table 28

The Percentage of Manufacturers' Facilities in Each Region

	FCA	Ford	GM	Honda	Hyundai	Kia	Nissan	PSA	Renault	Toyota	VW	Grand total
North America	18%	22%	33%	12%	1%	1%	4%	0%	0%	9%	1%	100%
Mexico	21%	13%	21%	13%	0%	0%	17%	0%	0%	4%	13%	100%
South America	11%	7%	14%	18%	2%	0%	5%	7%	9%	7%	20%	100%
EU	6%	8%	7%	3%	1%	1%	1%	18%	13%	3%	40%	100%
Other Europe	8%	24%	8%	8%	4%	0%	4%	8%	4%	8%	24%	100%
Asia	2%	9%	11%	21%	5%	2%	12%	2%	2%	18%	16%	100%
Southeast Asia and Oceania	2%	5%	3%	48%	0%	2%	13%	3%	0%	20%	5%	100%
Africa and Middle East	0%	9%	9%	14%	0%	0%	9%	14%	14%	14%	18%	100%
Grand total	**7%**	**11%**	**14%**	**16%**	**2%**	**1%**	**7%**	**7%**	**5%**	**11%**	**18%**	**100%**

Source: Manufacturers' corporate websites and annual reports, 2017

3.2. Fiat Chrysler Automobiles (FCA)

Headquarters: London, United Kingdom

Unit sales in 2017: 4,737,000

Employees in 2017: 235,915

Number of production facilities: 47

Annual reports:
https://www.fcagroup.com/en-US/investors/financial_regulatory/Pages/latest_financial_results.aspx

FCA 2016	Number of facilities
Argentina	1
Brazil	3
Canada	3
China	1
France	1
India	1
Italy	7
Japan	1
Mexico	5
Poland	1
Serbia	1
Thailand	1
Turkey	1
United States	19
Venezuela	1
Grand total	**47**

3.3. Ford Motor Company

Headquarters: Dearborn, Michigan, United States

Unit sales in 2017: 6,607,000

Employees in 2017: 202,000

Number of production facilities: 72

Annual reports: https://shareholde r.ford.com/home/default.aspx

Ford (2016)	Number of employees	Employee percentage	Sum of size (square meters)	Size percentage
North America	57,804	36%	6,786,984	46%
Canada	5,900	4%	879,234	6%
United States	51,904	32%	5,907,750	40%
Mexico	7,378	5%	620,859	4%
Mexico	7,378	5%	620,859	4%
South America	13,477	8%	1,211,562	8%
Brazil	11,005	7%	1,136,101	8%
Venezuela	2,472	2%	75,461	1%
European Union	24,612	15%	2,186,068	15%
France	1,888	1%	289,450	2%
Germany	13,958	9%	711,955	5%
Romania	3,600	2%	—	0%
Slovakia	835	1%	—	0%
Spain	4,331	3%	1,184,663	8%
United Kingdom	6,824	4%	579,315	4%
United Kingdom	6,824	4%	579,315	4%
Other Europe	7,887	5%	383,158	3%
Turkey	7,887	5%	383,158	3%
Russia & Kazakhstan	5,727	4%	541,588	4%
Russia	5,727	4%	541,588	4%
China (mainland) & Taiwan	18,815	12%	1,962,111	13%
China (mainland)	17,919	11%	1,467,307	10%
Taiwan	896	1%	494.804	3%
Japan		0%	—	0%
Japan		0%	—	0%
Indian Subcontinent	6,031	4%	84,125	1%
India	6,031	4%	84,125	1%
Southeast Asia & Oceania	9,597	6%	392,995	3%
Thailand	8,927	6%	365,124	2%
Vietnam	670	0%	27,871	0%
Africa & Middle East	3,558	2%	161,124	1%
South Africa	3,558	2%	161,124	1%
Grand total	**161,710**	**100%**	**14,909,888**	**100%**

Ford	Assembly	Casting & forging	Engines	Stamping	Transmission	Total
Brazil	1				1	2
Canada	1		2			3
China (mainland)	4		1		1	6
France					2	2
Germany	2	2	1		1	6
India	1		1			2
Japan					2	2
Mexico	2		1			3
Romania	1					1
Russia	3		1			4
Slovakia					1	1
South Africa	1		1			2
Spain	1		1			2
Taiwan	1		1			2
Thailand	2					2
Turkey	1		1			2
UK			3		1	4
United States	8	2	6	5	3	24
Venezuela	1					1
Vietnam	1					1
Grand total	**31**	**4**	**20**	**5**	**12**	**72**

3.4. General Motors

Headquarters: Detroit, Michigan, United States

Unit sales in 2017: 9,600,000

Employees in 2017: 180,000

Number of production facilities: 89

Annual reports: http://www.gm.com/mol/stockholder-information.html

General Motors	Number of facilities
Argentina	1
Austria	1
Brazil	3
Canada	4
China	11
Colombia	1
Ecuador	1
Egypt	1
France	2
Germany	3
Hungary	2
India	2
Japan	4
Mexico	5
Poland	1
Russia	1
South Africa	1
South Korea	3
Spain	2
Thailand	1
United Kingdom	2
United States	36
Vietnam	1
Grand total	**89**

3.5. Honda

Headquarters: Tokyo, Japan

Unit sales in 2016: 5,028,000

Employees: 203,902

Number of facilities: 102

Annual reports: https://global.honda/investors/

Honda	Number of facilities
Argentina	2
Australia	1
Bangladesh	1
Brazil	5
Canada	3
China (mainland)	15
France	1
India	6
Indonesia	9
Italy	2
Japan	12
Kenya	1
Malaysia	6
Mexico	3
Nigeria	2
Pakistan	3
Peru	1
Philippines	3
Spain	1
Taiwan	1
Thailand	5
Turkey	1
United Kingdom	1
United States	12
Vietnam	5
Grand total	**102**

3.6. Hyundai Motor Company

Headquarters: Seoul, South Korea

Unit sales in 2017: 4,507,000

Employees: 168,677 (automotive)

Number of production facilities: 21

Annual reports:
https://www.hyundai.com/worldwide/en/company/ir/financial-information/financial-statements

Hyundai	Number of facilities
Brazil	1
China	3
Czech Republic	1
India	2
Russia	1
South Korea	4
Turkey	1
United States	1
Grand total	**14**

Kia	Number of facilities
China	1
Slovakia	1
South Korea	3
United States	1
Vietnam	1
Grand total	**7**

3.7. Nissan

Headquarters: Yokohama, Japan

Unit sales in 2017: 5,770,000

Employees in 2017: 247,500

Number of production facilities: 46

Annual reports: http://www.nissan-global.com/EN/IR/LIBRARY/

Nissan	Number of facilities
Australia	1
Brazil	2
China (mainland)	6
Egypt	1
India	1
Indonesia	1
Japan	12
Malaysia	2
Mexico	4
Philippines	2
Russia	2
South Africa	1
Spain	2
Taiwan	1
Thailand	1
United Kingdom	1
United States	5
Vietnam	1
Grand total	**46**

3.8. PSA

Headquarters: Paris, France

Unit sales in 2017: 3,230,000

Employees in 2017: 208,000

Number of production facilities: 42

Annual reports: http://media.groupe-psa.com/en/psa-peugeot-citro%C3%ABn/publications

PSA	Number of facilities
Argentina	2
Austria	1
Brazil	1
China	2
Czech Republic	1
France	20
Iran	1
Italy	1
Japan	1
Kenya	1
Malaysia	1
Netherlands	1
Nigeria	1
Portugal	1
Russia	1
Slovakia	1
Spain	2
Turkey	2
Vietnam	1
Grand total	**42**

3.9. Renault Group

Headquarters: Boulogne-Billancourt, France

Unit sales in 2017: 3,761,634

Employees in 2017: 181,344

Number of production facilities: 32

Annual reports: https://group.renault.com/en/finance-2/

Renault	Number of facilities
Algeria	1
Argentina	1
Brazil	1
Chile	1
China	1
Colombia	1
France	13
India	1
Morocco	2
Portugal	1
Romania	1
Russia	1
Slovenia	1
South Korea	1
Spain	4
Turkey	1
Grand total	**32**

3.10. Toyota

Headquarters: Toyota city, Japan

Unit sales in 2016: 8,681,328

Employees: 348,877

Number of production facilities: 70

Annual reports: http://www.toyota-global.com/investors/financial_result/2015/

Toyota	Number of employees	Employee percentage
North America	32,697	14%
Canada	7,829	3%
United States	24,868	10%
Mexico	702	0%
Mexico	702	0%
South America	11,267	5%
Argentina	4,232	2%
Brazil	5,264	2%
Venezuela	1,771	1%
European Union	8,691	4%
Czech Republic	2,425	1%
France	3,638	2%
Poland	2,438	1%
Portugal	190	0%
United Kingdom	3,891	2%
United Kingdom	3,891	2%
Other Europe	3,300	1%
Turkey	3,300	1%
Russia & Kazakhstan	1,652	1%
Kazakhstan	0	0%
Russia	1,652	1%
China (mainland) & Taiwan	37,045	16%
China (mainland)	32,914	14%
Taiwan	4,131	2%
Japan	63,911	27%
Japan	63,911	27%
Indian Subcontinent	13,769	6%
Bangladesh	430	0%
India	11,034	5%
Pakistan	2,305	1%
Southeast Asia & Oceania	54,241	23%
Australia	4,183	2%
Indonesia	21,208	9%
Malaysia	3,013	1%
Philippines	3,285	1%
Thailand	20,882	9%
Vietnam	1,670	1%
Africa & Middle East	7,829	3%
Egypt	700	0%
Kenya	204	0%
South Africa	6,925	3%
Grand total	238,995	100%

Toyota	Number of facilities
Argentina	1
Australia	1
Bangladesh	1
Brazil	1
Canada	2
China (mainland)	9
Czech Republic	1
Egypt	1
France	1
India	2
Indonesia	4
Japan	17
Kazakhstan	1
Kenya	1
Malaysia	1
Mexico	1
Pakistan	1
Philippines	2
Poland	2
Portugal	1
Russia	1
South Africa	1
Taiwan	1
Thailand	3
Turkey	1
United Kingdom	1
United States	9
Venezuela	1
Vietnam	1
Grand total	**70**

3.11. Volkswagen

Headquarters: Wolfsburg, Germany

Unit sales in 2017: 13,135,000

Employees in 2017: 117,400

Number of production facilities: 118

Annual reports: https://www.volkswagenag.com/en/InvestorRelations/news-and-publications.html

Volkswagen	Number of employees	Employee percentage
North America	2,177	0%
United States	2,177	0%
Mexico	15,353	3%
Mexico	15,353	3%
South America	30,095	6%
Argentina	7,455	1%
Brazil	22,640	4%
European Union	336,489	64%
Austria	2,218	0%
Belgium	2,513	0%
Czech Republic	25,660	5%
Denmark	1,810	0%
France	1,300	0%
Germany	227,198	43%
Hungary	11,411	2%
Italy	2,470	0%
Netherlands	1,451	0%
Poland	14,170	3%
Portugal	3,419	1%
Slovakia	10,623	2%
Spain	18,411	3%
Sweden	13,835	3%
United Kingdom	4,025	1%
United Kingdom	4,025	1%
Other Europe	3,466	1%
Bosnia-Herzegovina	308	0%
Finland	204	0%
Switzerland	1,018	0%
Turkey	1,936	0%
Russia & Kazakhstan	4,455	1%
Russia	4,455	1%
China (mainland) & Taiwan	84,595	16%
China (mainland)	84,545	16%
Taiwan	50	0%
Indian Subcontinent	5,810	1%
India	5,810	1%
Southeast Asia & Oceania	506	0%
Malaysia	200	0%
Thailand	306	0%
South Korea	100	0%
South Korea	100	0%
Africa & Middle East	40,236	8%
South Africa	40,236	8%
Grand total	**527,307**	**100%**

Volkswagen	Number of facilities
Argentina	3
Austria	1
Belgium	1
Bosnia-Herzegovina	1
Brazil	6
China (mainland)	18
Czech Republic	4
Denmark	2
Finland	1
France	3
Germany	29
Hungary	1
India	6
Italy	2
Malaysia	1
Mexico	3
Netherlands	2
Poland	8
Portugal	1
Russia	3
Slovakia	2
South Africa	4
South Korea	1
Spain	4
Sweden	3
Switzerland	2
Taiwan	1
Thailand	2
Turkey	1
United Kingdom	1
United States	1
Grand total	**118**

4. Key Associations, Organizations and Industry Events

While subsequent sections go into more detail, the key information sources for the auto manufacturers, suppliers and dealers are as follows:

Manufacturers:

- Alliance of Automobile Manufacturers (Auto Alliance)

  https://autoalliance.org/

- European Automobile Manufacturers Association (ACEA)

  https://www.acea.be/

- Association of Global Automakers (Global Automakers)

  https://www.globalautomakers.org/

- International Organization of Motor Vehicle Manufacturers (OICA)

  http://www.oica.net/

Suppliers:

- European Association of Automotive Suppliers (Comité de liaison européen des fabricants d'équipements et de pièces automóviles, CLEPA)

  https://clepa.eu/

- Motor and Equipment Manufacturers Association (MEMA)

  https://www.mema.org/

Dealers:

- European Council for Motor Trades and Repairs (CECRA)

  https://www.cecra.eu/

- National Automobile Dealers Association (NADA)

  https://www.nada.org/

Subsequent sections organize the information sources by geographic region and/or supply-chain echelon. (Some of the information is therefore repeated.)

4.1. By Country

4.1.1. China

4.1.1.1. Auto Shanghai

Established in 1985, Auto Shanghai is the top automobile industry show in China. In 2015, the fair brought together exhibitors from 19 countries and hosted more than 900,000 visitors. Auto Shanghai takes place in Shanghai every other year in April.

Website: http://www.autoshanghai.org/?lang=en

4.1.1.2. China Association of Automobile Manufacturers (CAAM)

The China Association of Automobile Manufacturers was founded in Beijing in 1987. According to its website, "it is a self-discipline[d] and non-profit social organization formed based on the principle of equality and voluntariness." Its members include enterprises and organizations engaged in the production and management of automobiles and motorcycles, auto parts and vehicle-related industries "founded within the boundaries of the People's Republic of China."

As "one of the permanent and vice president members of the International Organization of Motor Vehicle Manufacturers (OICA)," CAAM "has established a close relationship with the international organization for automobile industry and the vehicle-related bodies in many countries and regions around the world."

Website: http://www.caam.org.cn/english/

4.1.2. United States

4.1.2.1. American International Automobile Dealers Association (AIADA)

> "Established in 1970, the American International Automobile Dealers Association (AIADA) is the only national trade association whose sole purpose is to represent America's 10,000 international nameplate automobile franchises. The association serves as an advocate for the industry before Congress, the White House, and federal agencies."

Website: https://www.aiada.org/

4.1.2.2. Center for Automotive Research (CAR)

> "The Center for Automotive Research, a nonprofit automotive research organization, has performed detailed studies of the contribution of the automotive industry and its value chain in the U.S. economy for more than 35 years.
>
> "CAR's mission is to conduct independent research and analysis to educate, inform and advise stakeholders, policy makers, and the general public on critical issues facing the automotive industry, and the industry's impact on the U.S. economy and society."

Website: https://www.cargroup.org/

4.1.2.3. Environmental Protection Agency (EPA)

The United States Environmental Protection Agency was established in 1970. “EPA’s purpose is to ensure that: all Americans are protected from significant risks to human health and the environment where they live, learn and work; national efforts to reduce environmental risk are based on the best available scientific information; [and] federal laws protecting human health and the environment are enforced fairly and effectively.”

Website: https://www.epa.gov/

4.1.2.4. International Trade Administration (ITA)

The International Trade Administration, an agency of the US Department of Commerce, “strengthens the competitiveness of U.S. industry, promotes trade and investment, and ensures fair trade through the rigorous enforcement of our trade laws and agreements.”

Website: https://www.trade.gov/index.asp

4.1.2.5. Motor and Equipment Manufacturers Association (MEMA)

The Motor and Equipment Manufacturers Association was set up in 1904 and has its headquarters in North Carolina. MEMA “has exclusively represented more than 1,000 companies that manufacture motor vehicle components and systems for the original equipment and aftermarket segments of the light vehicle and heavy-duty industries. MEMA advocates on behalf of suppliers on issues of legislative and regulatory interest to the industry.”

The MEMA network comprises four affiliate associations: Automotive Aftermarket Suppliers Association (AASA), Heavy Duty Manufacturers Association (HDMA), The Association for Sustainable Manufacturing (formerly the Motor and Equipment Remanufacturers Association) (MERA), and Original Equipment Suppliers Association (OESA).

Website: https://www.mema.org/

4.1.2.6. National Automobile Dealers Association (NADA)

The National Automobile Dealers Association was born in 1917, when a group of 30 auto dealers went to the US Congress to ask legislators not to impose a luxury tax on the automobile. They succeeded and formed a dealers association. Today, NADA represents nearly 16,000 dealers of new cars and trucks, with 32,500 franchises, both domestic and international.

Website: https://www.nada.org/

4.1.2.7. Bureau of Economic Analysis (BEA)

The Bureau of Economic Analysis of the US Department of Commerce “strives to provide the most timely, relevant, and accurate economic data” on the US economy.

Website: https://www.bea.gov/

4.1.2.8. Bureau of Labor Statistics (BLS)

The Bureau of Labor Statistics of the US Department of Labor is "the principal federal agency responsible for measuring labor market activity, working conditions, and price changes in the economy."

Website: https://www.bls.gov

4.1.2.9. North American International Auto Show (NAIAS)

The Detroit Auto Show was first held in 1907 and it became an international show in 1989, when it was renamed the North American International Auto Show. In 2015, the show brought together exhibitors from 25 countries and hosted around 800,000 visitors. The fair takes place in Detroit, Michigan, every January but, it will switch to June.

Website: https://naias.com/

4.1.2.10. Fuel Cell Technologies Office

Part of the US Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), "the Fuel Cell Technologies Office (FCTO) supports manufacturing research and development (R&D) activities to improve processes and reduce the cost of components and systems for hydrogen production, delivery, and storage over the range of fuel cell application areas, including stationary, portable, and transportation."

Website: https://www.energy.gov/eere/fuelcells/fuel-cell-technologies-office

4.1.3. Japan

4.1.3.1. Japan Automobile Manufacturers Association (JAMA)

"Established in 1967, the Japan Automobile Manufacturers Association, Inc. (JAMA) is a non-profit industry association which comprises Japan's fourteen manufacturers of passenger cars, trucks, buses and motorcycles. Its organization today is the result of the merger of Japan Motor Industrial Federation (JMIF) and Japan Automobile Industry Employers' Association (JAIEA) with JAMA in May 2002."

Website: http://www.jama-english.jp/

4.1.3.2. Statistics Bureau of Japan

The Statistics Bureau of Japan's Ministry of Internal Affairs and Communications "conducts fundamental censuses and statistical surveys."

Website: http://www.stat.go.jp/english/

4.1.3.3. Tokyo Motor Show

Established in 1954, the Tokyo Motor Show is an international show that takes place every other year in late October and early November. The fair hosted more than 900,000 visitors in 2013 although the number fell to 771,200 in 2017.

Website: https://www.tokyo-motorshow.com/en/

4.1.4. Germany

4.1.4.1. Association of International Motor Vehicle Manufacturers (VDIK)

The Association of International Motor Vehicle Manufacturers (Verband der Internationalen Kraftfahrzeughersteller, VDIK) was founded in Frankfurt am Main in 1952. The association says that today "almost all" the German branches of international motor vehicle manufacturers "with their more than 34 passenger car and commercial vehicle makes belong to the Association." Its mission includes "representing the interests of its members vis-à-vis law-makers, the government, government agencies, institutions, organizations" and the general public in Germany.

Website: http://www.vdik.de/home.html

4.1.4.2. Federal Association of Independent Motor Dealers (BVfK)

The Federal Association of Independent Motor Dealers (Bundesverband freier Kfz-Händler, BVfK) groups independent dealers in Germany.

Website (German only): https://www.bvfk.de/

4.1.4.3. International Motor Show (IAA)

First held in Berlin in 1897, Germany's International Motor Show (Internationale Automobil-Ausstellung, IAA) is one of the top automobile events in Europe. The show is held every September, with a passenger-car show held in Frankfurt in odd-numbered years and a commercial-vehicle show held in Hannover in even-numbered years. In 2013 the Frankfurt show brought together exhibitors from 35 countries and hosted more than 900,000 visitors.

Website: https://www.iaa.de/en/

4.1.4.4. German Association of the Automotive Industry (VDA)

The German Association of the Automotive Industry (Verband der Automobilindustrie, VDA) has more than 600 member companies, which produce motor vehicles, trailers, body structures, buses, and vehicle parts and accessories.

Website: https://www.vda.de/en

4.1.5. South Korea

4.1.5.1. Korea Automobile Manufacturers Association (KAMA)

The Korea Automobile Manufacturers Association is a nonprofit organization that represents the interests of automakers in South Korea. The association is also "dedicated to the sound growth of the automobile industry and the development of the national economy."

Website: http://www.kama.or.kr/MainController?cmd=eng

4.1.6. India

4.1.6.1. Automotive Component Manufacturers Association of India (ACMA)

The Automotive Component Manufacturers Association of India represents 780 companies, which together contribute more than 85% of the country's total auto-component output. These companies "supply components to vehicle manufacturers as original equipment, to tier-one suppliers, to state transport undertakings, defence establishments, railways, and even to the replacement market."

Website: http://www.acmainfo.com/

4.1.6.2. Society of Indian Automobile Manufacturers (SIAM)

The Society of Indian Automobile Manufacturers represents 46 "leading vehicle and vehicular engine manufacturers in India." SIAM is "an important channel of communication" between the automobile industry and the government.

Website: http://www.siamindia.com

4.1.7. Mexico

4.1.7.1. Mexican Association of the Automotive Industry (AMIA)

The Mexican Association of the Automotive Industry (Asociación Mexicana de la Industria Automotriz, AMIA) was created in 1951 by the following vehicle manufacturers: Chrysler de México SA de CV, Ford Motor Co. SA de CV, General Motors de México S de RL de CV, Nissan Mexicana SA de CV, and Volkswagen de México SA de CV.

Website (Spanish only): http://www.amia.com.mx

4.1.7.2. National Auto Parts Industry (INA)

What is now the National Auto Parts Industry (Industria Nacional de Autopartes, INA) was set up in 1961 at the time of negotiations over Mexico's first Automotive Decree of 1962, when the pioneering automotive manufacturers saw the need to establish a joint negotiation group in order to represent their interests meaningfully to the government authorities.

Website (Spanish only): http://www.ina.com.mx/

4.1.8. Brazil

4.1.8.1. National Association of Motor Vehicle Manufacturers (ANFAVEA)

The National Association of Motor Vehicle Manufacturers (Associação Nacional dos Fabricantes de Veículos Automotores, ANFAVEA) was founded in 1956. It brings together manufacturers of vehicles (cars, light commercial vehicles, trucks and buses) and agricultural machinery (wheeled and crawler tractors, combine harvesters and backhoes) in Brazil.

Website (Portuguese only): http://www.anfavea.com.br/

4.1.8.2. National Union of the Motor-Vehicle Component Industry (Sindipeças)

The National Union of the Motor-Vehicle Component Industry (Sindicato Nacional da Indústria de Componentes para Veículos Automotores, Sindipeças) represents about 95% of the auto-part industry in Brazil, covering both national and international companies.

Website (Portuguese, English and Spanish): http://www.sindipecas.org.br/

4.1.9. Spain

4.1.9.1. Spanish Association of Car and Truck Manufacturers (Anfac)

Established in 1977, the Spanish Association of Car and Truck Manufacturers (Asociación Española de Fabricantes de Automóviles y Camiones, Anfac) is a nonprofit association that aims to promote the appropriate development of the automotive sector in Spain and defend its interests by promoting collaboration among manufacturers of vehicles and related products in Europe.

Website (Spanish only): http://www.anfac.com

4.1.9.2. Spanish Association of Automotive Suppliers (SERNAUTO)

Founded in 1967, the Spanish Association of Automotive Suppliers (Asociación Española de Proveedores de Automoción, SERNAUTO) represents Spain's auto-component industry.

Website: http://www.sernauto.es/en

4.1.9.3. Federation of Automotive Dealer Associations (Faconauto)

The Federation of Automotive Dealer Associations (Federación de Asociaciones de Concesionarios de la Automoción, Faconauto) groups the associations of official dealers of the Spanish market's car brands. The federation represents 2,087 car and 311 commercial-vehicle dealers.

Website (Spanish only): https://www.faconauto.com/

4.1.9.4. IESE Auto Meeting

Established in 1985, the IESE Auto conference is the top car event in Spain. Organized by IESE Business School, it takes place in Barcelona every November.

Website: https://industrymeetings.iese.edu/meeting/33rd-iese-auto/

4.1.10. Canada

4.1.10.1. Automotive Industries Association (AIA)

The Automotive Industries Association represents the automotive aftermarket industry in Canada. The industry is composed of companies that manufacture, distribute and install automotive replacement parts, accessories, tools, and equipment. The association's mission "is to promote, educate and represent members in all areas that impact the growth and prosperity of the industry."

Website: https://aiacanada.com

4.1.10.2. Automotive Parts Manufacturers' Association (APMA)

The Automotive Parts Manufacturers' Association is "Canada's national association representing OEM producers of parts, equipment, tools, supplies, advanced technology, and services for the worldwide automotive industry."

The association was founded in 1952 and its hundreds of members "account for 90% of independent parts production in Canada."

Website: https://apma.ca/

4.1.10.3. Canadian Automobile Dealers Association (CADA)

The Canadian Automobile Dealers Association is the national association for franchised dealerships that sell new cars and trucks.

Website: http://www.cada.ca/

4.1.10.4. Canadian Vehicle Manufacturers' Association (CVMA)

The Canadian Vehicle Manufacturers' Association is the industry association representing Canada's largest manufacturers of light and heavy-duty motor vehicles. Its members include FCA Canada Inc., Ford Motor Company of Canada Ltd., General Motors of Canada Ltd., and Navistar Canada Inc.

"The CVMA creates a framework within which member companies work together to achieve shared industry objectives on a range of important issues such as consumer protection, the environment and vehicle safety."

Website: http://www.cvma.ca

4.1.10.5. Global Automakers of Canada (GAC)

"Global Automakers of Canada (GAC) evolved from a sub-committee within the Canadian Importers Association in 1979, to become an independently incorporated, not-for-profit association in 1999. The GAC represents before federal, provincial and territorial governments the interests of members engaged in the manufacturing, importation, distribution and servicing of light duty vehicles. While the Association was initially dedicated to the interests of importers, it has broadened its focus as offshore-based companies have set up vehicle manufacturing plants in Canada."

Website: http://globalautomakers.ca/

4.1.11. United Kingdom

4.1.11.1. Society of Motor Manufacturers and Traders (SMMT)

"The Society of Motor Manufacturers and Traders (SMMT) is one of the largest and most influential trade associations in the UK. […] SMMT represents more than 800 automotive companies in the UK, providing them with a forum to voice their views on issues affecting the sector, helping to guide strategies and build positive relationships with government and regulatory authorities."

Website: https://www.smmt.co.uk/

4.2. Regional

4.2.1. Europe

4.2.1.1. European Automobile Manufacturers Association (ACEA)

The European Automobile Manufacturers Association (Association des constructeurs européens d'automobiles, ACEA), founded in 1991, "represents the 15 major Europe-based car, van, truck and bus makers: BMW Group, DAF Trucks, Daimler, Fiat Chrysler Automobiles, Ford of Europe, Honda Motor Europe, Hyundai Motor Europe, Iveco, Jaguar Land Rover, PSA Group, Renault Group, Toyota Motor Europe, Volkswagen Group, Volvo Cars, and Volvo Group."

Website: https://www.acea.be/

4.2.1.2. European Association of Automotive Suppliers (CLEPA)

The European Association of Automotive Suppliers (Comité de liaison européen des fabricants d'équipements et de pièces automobiles, CLEPA) was created in 1959 by several national associations representing automotive suppliers. Their aim was to establish a representation office in Brussels that would deal mainly with the issue of technical regulations, which the recently founded European Economic Community was starting to define.

CLEPA "brings together over 120 global suppliers of car parts, systems and modules and more than 20 national trade associations and European sector associations."

Website: https://clepa.eu/

4.2.1.3. European Car Dealer Association (ECDA)

The European Car Dealer Association, based in Brussels, represents European vehicle traders. "More than 200 European free vehicle traders are organised in ECDA."

Website: http://www.ecda.de/

4.2.1.4. European Central Bank (ECB)

The European Central Bank administers monetary and exchange-rate policies in the eurozone.

Website: https://www.ecb.europa.eu/

4.2.1.5. Eurostat

Eurostat is the statistical office of the European Union, located in Luxembourg. Its main task is to provide "statistics at European level that enable comparisons between countries and regions."

Website: https://ec.europa.eu/eurostat/

4.2.1.6. European Council for Motor Trades and Repairs (CECRA)

The European Council for Motor Trades and Repairs (CECRA) was established in 1983 and "brings together 24 national professional associations representing the interests of motor trade and repair business, and 12 European Dealer Councils representing vehicle dealers."

Website: https://www.cecra.eu/

4.2.1.7. European Environment Agency (EEA)

In 1990, the European Community adopted a regulation establishing the European Environment Agency, which "began its work in earnest in 1994." The EEA is "an agency of the European Union, whose task is to provide sound, independent information on the environment." The EEA is a major information source for those involved in developing, adopting, implementing and evaluating environmental policy. It has 33 member countries.

Website: https://www.eea.europa.eu/

4.2.1.8. Geneva International Motor Show

Established in 1905, the Geneva International Motor Show takes place in the Swiss city every March. In 2018, the show hosted more than 660,000 visitors.

Website: https://www.gims.swiss/

4.2.1.9. Mondial Paris Motor Show

Established in 1898, the Mondial Paris Show (previously known as the Mondial de l'Automobile) is one of the most-visited auto fairs in the world. It takes place in the French capital every other year in October. In 2016, the show welcomed more than 1.07 million visitors.

Website: https://www.mondial-paris.com/en/visiteur/auto

4.2.1.10. HyFive

The European project HyFIVE (Hydrogen for Innovative Vehicles) involves 15 partners, which will deploy 185 fuel-cell electric vehicles (FCEVs) produced by the five global automotive companies playing a leading role in the vehicles' commercialisation: BMW, Daimler, Honda, Hyundai and Toyota.

The project will create clusters of refueling station networks in three areas of Europe, where there will be a sufficient density of hydrogen stations to provide refueling choice and convenience to early users of FCEVs.

Website: http://www.hyfive.eu/

4.2.2. North America

4.2.2.1. Alliance of Automobile Manufacturers (Auto Alliance)

"The Alliance of Automobile Manufacturers represents 70% of all car and light truck sales in the United States, including the BMW Group, Fiat Chrysler Automobiles, Ford Motor Company, General Motors Company, Jaguar Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche, Toyota, Volkswagen Group of America and Volvo Car USA."

Website: https://autoalliance.org/

4.2.2.2. North American Automobile Trade Association (NAATA)

The North American Automobile Trade Association was founded in 1996 to represent vehide importers and exporters dealing in motor vehicles originating in the United States, Canada, and Mexico.

Website: https://naatatrade.org/

4.2.3. Asia

4.2.3.1. ASEAN Automotive Federation (AAF)

"The ASEAN Automotive Federation was first established in 1976, but activities ceased in 1983 as the National Automotive Associations in each ASEAN country focussed their efforts to develop their respective national automotive industry." In 1996, ASEAN Automotive Federation "was revived as a common platform to work with ASEAN governments."

Website: http://www.asean-autofed.com/

4.2.4. Latin America

4.2.4.1. Latin American Automobile Dealers Association (ALADDA)

Established in 1974, the Latin American Automobile Dealers Association (Asociación Latinoamericana de Distribuidores de Automotores, ALADDA) brings together national dealer associations from the following Latin American countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. The National Automobile Dealers Association of the United States joined in 2007.

4.3. International

4.3.1. Automotive Parts Remanufacturers Association (APRA)

The Automotive Parts Remanufacturers Association was founded in 1941 in the California city of Los Angeles. As of 2016, its membership had grown to "about 1,000 member companies worldwide."

Website: https://apra.org/

4.3.2. Association of Global Automakers (Global Automakers)

Established in 1961, Global Automakers is "the voice of international automobile manufacturers that design, build, and sell motor vehicles in the United States."

Website: https://www.globalautomakers.org/

4.3.3. International Monetary Fund (IMF)

Created in 1945, the International Monetary Fund (IMF) is "an organization of 189 countries, working to foster global monetary cooperation, secure financial stability, facilitate international trade, promote high employment and sustainable economic growth, and reduce poverty around the world."

Website: https://www.imf.org/

4.3.4. International Organization of Motor Vehicle Manufacturers (OICA)

The International Organization of Motor Vehicle Manufacturers (Organisation internationale des constructeurs d'automobiles, OICA) was founded in Paris in 1919. "The general purposes of the organization are to defend the interests of the vehicle manufacturers, assemblers and importers grouped within their national federation."

Website: http://www.oica.net/

4.3.5. SAE International

SAE International, formerly the Society of Automotive Engineers, is "a global association of more than 128,000 engineers and related technical experts in the aerospace, automotive and commercial-vehicle industries." Its "core competencies are life-long learning and voluntary consensus standards development."

Website: https://www.sae.org/

4.3.6. United Nations International Trade Statistics Database (UN Comtrade)

The United Nations International Trade Statistics Database (UN Comtrade) is a repository of "detailed merchandise trade data" (by commodity category and trading partner).

Website: https://comtrade.un.org/

4.3.7. WardsAuto

WardsAuto is an information center that "has covered the global auto industry for more than 80 years, serving those within automakers, dealerships, suppliers and others serving or observing the industry with a wide range of information products. WardsAuto's flagship product is WardsAuto.com, a comprehensive online resource and community filled with unique news, data and analysis, with full access available as a premium subscription."

Website: https://www.wardsauto.com/

4.3.8. World Bank Group (WB)

The World Bank is an international financial institution that promotes employment, economic growth and poverty reduction around the world, providing loans to developing countries for capital programs.

Website: http://www.worldbank.org/

4.3.9. World Trade Organization (WTO)

Established in 1995, the Geneva-based World Trade Organization is “the only global international organization dealing with the rules of trade between nations. At its heart are the WTO agreements, negotiated and signed by the bulk of the world’s trading nations and ratified in their parliaments. The goal is to help producers of goods and services, exporters, and importers conduct their businesses.”

Website: https://www.wto.org/

4.4. Manufacturers

4.4.1. Alliance of Automobile Manufacturers (Auto Alliance)

“The Alliance of Automobile Manufacturers represents 70% of all car and light truck sales in the United States, including the BMW Group, Fiat Chrysler Automobiles, Ford Motor Company, General Motors Company, Jaguar Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche, Toyota, Volkswagen Group of America and Volvo Cars USA.”

Website: https://autoalliance.org/

4.4.2. Spanish Association of Car and Truck Manufacturers (Anfac)

Established in 1977, the Spanish Association of Car and Truck Manufacturers (Asociación Española de Fabricantes de Automóviles y Camiones, Anfac) is a nonprofit association that aims to promote the appropriate development of the automotive sector in Spain and defend its interests by promoting collaboration among manufacturers of vehicles and related products in Europe.

Website (Spanish only): http://www.anfac.com

4.4.3. Mexican Association of the Automotive Industry (AMIA)

The Mexican Association of the Automotive Industry (Asociación Mexicana de la Industria Automotriz, AMIA) was created in 1951 by the following vehicle manufacturers: Chrysler de México SA de CV, Ford Motor Co. SA de CV, General Motors de México S de RL de CV, Nissan Mexicana SA de CV, and Volkswagen de México SA de CV.

Website (Spanish only): http://www.amia.com.mx/

4.4.4. National Association of Motor Vehicle Manufacturers (ANFAVEA)

The National Association of Motor Vehicle Manufacturers (Associação Nacional dos Fabricantes de Veículos Automotores, Anfavea) was founded in 1956. It brings together manufacturers of vehicles (cars, light commercial vehicles, trucks and buses) and agricultural machinery (wheeled and crawler tractors, combine harvesters and backhoes) in Brazil.

Website (Portuguese only): http://www.anfavea.com.br/

4.4.5. European Automobile Manufacturers Association (ACEA)

The European Automobile Manufacturers Association (Association des constructeurs européens d'automobiles, ACEA), founded in 1991, "represents the 15 major Europe-based car, van, truck and bus makers."

Website: https://www.acea.be/

4.4.6. Association of International Motor Vehicle Manufacturers (VDIK)

The Association of International Motor Vehicle Manufacturers (Verband der Internationalen Kraftfahrzeughersteller, VDIK) was founded in Frankfurt am Main in 1952. The association says that today "almost all" the German branches of international motor vehicle manufacturers "with their more than 34 passenger car and commercial vehicle makes belong to the Association." Its mission includes "representing the interests of its members vis-à-vis law-makers, the government, government agencies, institutions, organizations" and the general public in Germany.

Website: http://www.vdik.de/home.html

4.4.7. Canadian Vehicle Manufacturers' Association (CVMA)

The Canadian Vehicle Manufacturers' Association is the industry association representing Canada's largest manufacturers of light and heavy-duty motor vehicles. Its members include FCA Canada Inc., Ford Motor Company of Canada Ltd., General Motors of Canada Ltd., and Navistar Canada Inc.

"The CVMA creates a framework within which member companies work together to achieve shared industry objectives on a range of important issues such as consumer protection, the environment and vehicle safety."

Website: http://www.cvma.ca

4.4.8. China Association of Automobile Manufacturers (CAAM)

The China Association of Automobile Manufacturers was founded in Beijing in 1987. According to its website, "it is a self-discipline[d] and non-profit social organization formed based on the principle of equality and voluntariness." Its members include enterprises and organizations engaged in the production and management of automobiles and motorcycles, auto parts and vehicle-related industries "founded within the boundaries of the People's Republic of China."

Website: http://www.caam.org.cn/english/

4.4.9. Association of Global Automakers (Global Automakers)

Established in 1961, Global Automakers is "the voice of international automobile manufacturers that design, build, and sell motor vehicles in the United States."

Website: https://www.globalautomakers.org/

4.4.10. Japan Automobile Manufacturers Association (JAMA)

"Established in 1967, the Japan Automobile Manufacturers Association, Inc. (JAMA) is a non-profit industry association which comprises Japan's fourteen manufacturers of passenger cars, trucks, buses and motorcycles. Its organization today is the result of the merger of Japan Motor Industrial Federation (JMIF) and Japan Automobile Industry Employers' Association (JAIEA) with JAMA in May 2002."

Website: http://www.jama-english.jp/

4.4.11. Korea Automobile Manufacturers Association (KAMA)

The Korea Automobile Manufacturers Association is a nonprofit organization that represents the interests of automakers in South Korea. The association is also "dedicated to the sound growth of the automobile industry and the development of the national economy."

Website: http://www.kama.or.kr/MainController?cmd=eng

4.4.12. Society of Indian Automobile Manufacturers (SIAM)

The Society of Indian Automobile Manufacturers represents 46 "leading vehicle and vehicular engine manufacturers in India." SIAM is "an important channel of communication" between the automobile industry and the government.

Website: http://www.siamindia.com

4.5. Suppliers

4.5.1. Spanish Association of Automotive Suppliers (SERNAUTO)

Founded in 1967, the Spanish Association of Automotive Suppliers (Asociación Española de Proveedores de Automoción, SERNAUTO) represents Spain's auto-component industry.

Website: http://www.sernauto.es/en

4.5.2. Automotive Component Manufacturers Association of India (ACMA)

The Automotive Component Manufacturers Association of India represents 780 companies, which together contribute more than 85% of the country's total auto-component output. These companies "supply components to vehicle manufacturers as original equipment, to tier-one suppliers, to state transport undertakings, defence establishments, railways, and even to the replacement market."

Website: http://www.acmainfo.com/

4.5.3. Automotive Parts Manufacturers' Association (APMA)

The Automotive Parts Manufacturers' Association is "Canada's national association representing OEM producers of parts, equipment, tools, supplies, advanced technology, and services for the worldwide automotive industry."

The association was founded in 1952 and its hundreds of members "account for 90% of independent parts production in Canada."

Website: https://apma.ca/

4.5.4. Automotive Parts Remanufacturers Association (APRA)

The Automotive Parts Remanufacturers Association was founded in 1941 in the California city of Los Angeles. As of 2016, its membership had grown to "about 1,000 member companies worldwide."

Website: https://apra.org/

4.5.5. National Union of the Motor-Vehicle Component Industry (Sindipeças)

The National Union of the Motor-Vehicle Component Industry (Sindicato Nacional da Indústria de Componentes para Veículos Automotores, Sindipeças) represents about 95% of the auto-part industry in Brazil, covering both national and international companies.

Website (Portuguese, English and Spanish): http://www.sindipecas.org.br/

4.5.6. European Association of Automotive Suppliers (CLEPA)

The European Association of Automotive Suppliers (Comité de liaison européen des fabricants d'équipements et de pièces automobiles, CLEPA) was created in 1959 by several national associations representing automotive suppliers. Their aim was to establish a representation office in Brussels that would deal mainly with the issue of technical regulations, which the recently founded European Economic Community was starting to define.

CLEPA "bring together over 120 global suppliers of car parts, systems and modules and more than 20 national trade associations and European sector associations."

Website: https://clepa.eu/

4.5.7. National Auto Parts Industry (INA)

What is now Mexico's National Auto Parts Industry (Industria Nacional de Autopartes, INA) was set up in 1961 at the time of negotiations over the country's first Automotive Decree of 1962, when the pioneering automotive manufacturers saw the need to establish a joint negotiation group in order to represent their interests meaningfully to the government authorities.

Website (Spanish only): http://www.ina.com.mx/

4.5.8. Motor and Equipment Manufacturers Association (MEMA)

The Motor and Equipment Manufacturers Association was set up in 1904 and has its headquarters in North Carolina. MEMA "has exclusively represented more than 1,000 companies that manufacture motor vehicle components and systems for the original equipment and aftermarket segments of the light vehicle and heavy-duty industries. MEMA advocates on behalf of suppliers on issues of legislative and regulatory interest to the industry."

The MEMA network comprises four affiliate associations: Automotive Aftermarket Suppliers Association (AASA), Heavy Duty Manufacturers Association (HDMA), The Association for Sustainable Manufacturing (formerly the Motor and Equipment Remanufacturers Association) (MERA), and Original Equipment Suppliers Association (OESA).

Website: https://www.mema.org/

4.6. Dealers

4.6.1. American International Automobile Dealers Association (AIADA)

"Established in 1970, the American International Automobile Dealers Association (AIADA) is the only national trade association whose sole purpose is to represent America's 10,000 international nameplate automobile franchises. The association serves as an advocate for the industry before Congress, the White House, and federal agencies."

Website: https://www.aiada.org/

4.6.2. Latin American Automobile Dealers Association (ALADDA)

Established in 1974, the Latin American Automobile Dealers Association (Asociación Latinoamericana de Distribuidores de Automotores, ALADDA) brings together national dealer associations from the following Latin American countries: Argentina, Bolivia, Brazil, Chile, Colombia, Cosa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. The National Automobile Dealers Association of the United States joined in 2007.

4.6.3. Canadian Automobile Dealers Association (CADA)

The Canadian Automobile Dealers Association is the national association for franchised dealerships that sell new cars and trucks.

Website: http://www.cada.ca/

4.6.4. European Car Dealer Association (ECDA)

The European Car Dealer Association, based in Brussels, represents European vehicle traders. "More than 200 European free vehicle traders are organised in ECDA."

Website: http://www.ecda.de/

4.6.5. European Council for Motor Trades and Repairs (CECRA)

The European Council for Motor Trades and Repairs (CECRA) was established in 1983 and "brings together 24 national professional associations representing the interests of motor trade and repair business, and 12 European Dealer Councils representing vehicle dealers."

Website: https://www.cecra.eu/

4.6.6. Federation of Automotive Dealer Associations (Faconauto)

The Federation of Automotive Dealer Associations (Federación de Asociaciones de Concesionarios de la Automoción, Faconauto) groups the associations of official dealers of the Spanish market's car brands. The federation represents 2,087 car and 311 commercial-vehicle dealers.

Website (Spanish only): https://www.faconauto.com/

4.6.7. Federal Association of Independent Motor Dealers (BVfK)

The Federal Association of Independent Motor Dealers (Bundesverband freier Kfz-Händler, BVFK) groups independent dealers in Germany.

Website (German only): https://www.bvfk.de/

4.6.8. National Automobile Dealers Association (NADA)

The National Automobile Dealers Association was born in 1917, when a group of 30 auto dealers went to the US Congress to ask legislators not to impose a luxury tax on the automobile. They succeeded and formed a dealers association. Today, NADA represents nearly 16,000 dealers of new cars and trucks, with 32,500 franchises, both domestic and international.

Website: https://www.nada.org/

4.6.9. North American Automobile Trade Association (NAATA)

The North American Automobile Trade Association was founded in 1996 to represent vehide importers and exporters dealing in motor vehicles originating in the United States, Canada, and Mexico.

Website: https://naatatrade.org/

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