POLITECNICO DI TORINO

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MS in Management and Engineering

An analysis of the German used car market

Thesis supervisor:
Dr. Luigi Benfratello

Thesis candidate:
Francesco G. Bucciarelli

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Be kind whenever possible. It is always possible.
Dalai Lama

Acknowledgements

Ancora una volta mi ritrovo a concludere un percorso non solo di formazione, ma soprattutto di vita. Non posso non dare una grandissima parte del merito ai miei genitori, mia mamma Anna e mio papà Josè che non mi hanno mai abbandonato e mi hanno supportato in questa avventura, dandomi preziosi consigli e facendomi sentire sempre apprezzato e sentito a casa nonostante la distanza che ci separava.

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Grazie a tutti.

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Abstract

Since I was a child I was passionate about cars and curious about driving them. Upon reaching legal age I started to drive the one of my parents and later on I had the necessity to buy one for the purpose to go to work. In that particular moment I was at a crossroads, buy a new car or an used one? At the end the latter won, but the question remains:

what is that influence the price of an used car? And in what extent?

The analysis was done on a database of the German used cars from the website *autoscout24*, comparing the actual purchase price, with the same used model. The purchase price of the new cars were taken by the website of the car brand, if the model are still in production. The results shows a strong correlation between km,age and depreciation of the vehicle, where older and more chilometers the vehicle has, more such vehicle is depreciated. Further analysis can be conducted introducing the variable of the specific type of engine equiped by the vehicle in order to add a reliability layer, taking into account the specific engine used for the specific vehicle.

Introduction

Cars. The automobile is unquestionably one of the invention that changed radically the humankind perception of time and distances and shaped entirely the cities around the globe, shifting from human-centerd to car-centered cities. Invented at the end of the XIX century and developed during the XX century, where early adopters were filthy rich people who bought the automobile to show their wellness and to go in the country-side from the first big cities to have a nice Sunday evening, a complete different compared to nowadays.

Across the 2 World Wars, especially in the second one, the automobile changed absolutely the logistic in the war theater, providing a fast transportation system to deliver goods and deploy soldiers in a rapid way, in difficult points, without the necessity of an existing infrastructure, determining the victory or defeat in a battle.

After the WWII, during the post-war era, the automobile symbolized the re-birth after the destruction[1] and general wealth for a new middle class rising during those years. Massive car infrastructure was being built in the same period, providing a freedom of movement within and between countries. Famous car models of this period are the *FIAT 500* and *Volkswagen Type 1*[2].

During the XX century new car brands were founded and some went bankrupt or absorbed by bigger car manufacturers. In the recent days cars are widely used, currently the most used private transportation system used in Europe[3], with differences between countries.

[1] In the Continental Europe

[2] Known as Beetle in United States and Maggiolino or Maggiolone in Italy according estetic differences introduced during the years

[3] *Key figures on European transport* - 2022 Eurostat

Chapter 1

The Automobile

Any colour - so long as it's black
Henry Ford

The necessity to move is inherent in the human condition.

Since the beginning of humankind there was the necessity to move across the globe in order to find the best spot to settle. Starting more than 2 million years ago, the *Homo Erectus* started to migrate from the Sub-Saharian area to the European continent and the Middle East, reaching the East Asia and then the Americas through the Bearing strait.

During the first settlements and cities there was the necessity to communicate and to transport goods between such communities. The only way to do such essential activity for many centuries was using the animals' muscular power, specifically the horses, with carts or carriages.

This method was efficient for that time, since was the only at disposal. [1] The invention of the *steam power* engine provided the possibility to move faster and more efficiently.

The steam engine was a disruptive invention that cause the first industrial revolution and a consequence of a new way to see the transportation, no more with muscolar power, but with fuel powered machines. Since the steam engine new technologies were created and new material used, to reach the invention of the internal combustion engine as we know today, and the rest is history.

[1] Is not take into account ships, since the scope is about ground movements.

1.1 The history of the automobile - From the steam engine to the internal combustion engine

The necessity to shift the power production from animal source has its roots in the past. The first steam engine was theorized by Vitruvio in his book *De Architectura*, called *Aeolipilae* and describing it as:

Vas rotundum caeleste, aquae plenum, quod, per tubulos emissarios vaporis impetus, rotat.

"A round, celestial vessel, filled with water, which, through pipes emitting steam, is pushed and rotates."

This remains purely a description, with no practical use and without a practical realization. Only around the first century, the mathematician and engineer Hero of Alexandria produced the Aeolipilae, used only as a "party trick" built for curiosity for Hero and other mathematicians.

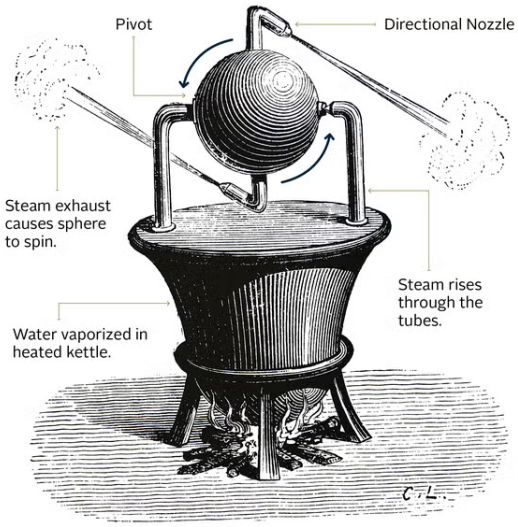

Figure 1.1: Hero's Aeolipilae

As showed in the picture, the steam power, through the directional nozzles and the steam exhaust, caused the sphere to rotate. Unfortunately this technology was used only for ricreational purpose, without a real application.

Centuries later, in Europe, the spanish inventor *Jerónimo de Ayanz y Beaumont* patented the first steam powered water pumps, with the goal to use this invention to drain mines. Even tough Jerònimo de Ayanz y Beaumont were the first to patent a steam powered device, the owner of the invention of the steam powered engine is *Thomas Savery*, the producer of the first commercially used steam powered device. The invention of the steam power engine revolutionized the industry, providing "endless and tireless"[2] power. This changed completely the production methods and started to shaped the society and cities we live in.

Something that changed definitely with the steam engine, and what they are known for, is the transportation. With the steam engine were built "special wagons", called *trains*. Trains were moved by steam engines and only in railways. The trains being faster than horse wagon, could transport more people and material, for longer distances. The application of the steam engine to substitute the old friend, the horse, was soon to be done. During the XIX century the inventor Richard Trevithick developed the use of high-pressure steam for steam engines, providing the possibility to make them smaller and therefore installed in wagons to substitute the horse power. Unfortunately the legislation limited severely the use of steam-powered vehicles, therefore the innovation in that direction stopped and focused more on trains and boats.

During those years also the electrical cars were developed. As well many investors and engineers were developing ways to produce, stock and use electricity as a source of power. During the century were developed electric motors and small electric powered car, developed by Anyos Jedlik. Due the lack of maturity of both electrical engines and batteries, providing only limited range, the internal combustion engines won the technological race at that time, and the infrastructure was built accordingly.

The powertrain that won the technological race and became later on the most used is the Internal Combustion Engine[3]. The ICE was created with two different combustion cycles, called *Otto* cycle and *Diesel* Cycle, respectively gasoline and diesel engine. The first modern car, commercially available and made to use it everyday, was made by Carl Benz, a patented gasoline-powered automobile in 1885. After the Benz's invention, many car brands were born and many failed, trying to produce and sell the best car. Many car race were born, trying to show how fast the automobile can be,

[2]The energy produced was related only to the amount of the fuel on disposal and to the engine reliability.

[3]The Internal Combustion Engine is commonly referred as ICE.

cities started to change their shapes, instead of being man-centered, with a Reinessance phylosophy, cities started to make space for the automobile, houses start to have garages and parking lots and highways and freeways started to be built to reach different cities faster, shaping the infrastructure as we know it today.

Though the car was patented by Mercedes, we owe to Henry Ford the realization of the first mass produced automobile, the *Ford T*. More than 15 million units produced. It was the first affordable car that could be afforded by the middle class, the class that in those years was rising, and demanding a better quality of life.

Figure 1.2: Ford Model T - 1908

The Model T was so popular Henry Ford once said: "There's no use trying to pass a Ford, because there's always another one just ahead." By the early 1920s more than half of the registered automobiles in the world were Fords. More than 15,000,000 Model T's were built and sold. In May 1927 a ceremony was held to honor the end of production of the Model T, determining the end of an era.[4]

[4]From the Corporate Ford website, https://corporate.ford.com/articles/history/the-model-t.html

1.2 Main structure system of an automobile

Define a main structure for the automobile is a difficult task, since can be deprimental because can aggregate in a structure some parts that need a system per se. The goal to define a main components list for an automobile is to list the main characteristics of an automobile to better understand how it works.

A division of the parts that make an automobile can be the following[5]:

- *Chassis* : is the weight supporting framework of the automobile. Carmakers produce a particular platform and on that specific one produce different type of vehicles. For example the STLA Medium is used on several models such as: Peugeot e-3000, Peugeout e-5008 and Open Grandland. This particular approach offers economies of scale, but limit the different car size possible.

- *Electronics* : key characteristic of today automobiles, aquired more and more importance in the last years. Infotainment, ADAS, cameras and self driving cars are the last improvements on electronics in the automotive sector.

- *Exterior* : is the combination of all the external aesthetic parts of an automobile. These parts give to the automobile its particular look and characters.

- *Interior* : is the combination of all the functional and aesthetic parts inside the vehicle. Interiors change according different models and price range, using different materials and adding different features.

- *Powertrain* : the combination of all the parts that allow the car to move, change direction, be on road and stop. Even though the engine seems to be the most important part, the powetrain all together define how safe and comfortable the car is. Is not the main indicator for reliability in a vehicle, even tough is the most important.

This particular division does not consider for example safety features[6] or new technological features that have particular relevance like infotainment.

[5]T.Klier & J.Rubenstein - The Parts of Your Vehicle - W.E. Upjohn Institute for Employment Research 2009

[6]Safety features can be added, without considering the law requirement like seat belt or ADAS that are mandatory in all new vehicles produced after January 1st 2025. - New rules on vehicle safety and automated mobility.

1.3 Powertrains & Segments

Besides different models and brand, the automobiles can be categorized according the different powertrain they are sold. Previously we defined the powertrain as all the components that allow the car to move. This particular components are engine specific in some cases; for example if the engine of a vehicle is diesel, then will have also the AdBlue® system, if it is gasoline, this system will not be present.

The following is a categorization of different powetrain available in the market. The list will not include niche powetrain, but examines the main one used in the industry.

1.3.1 Internal Combustion Engine

Here is reported a list of the internal combustion engines divided by its different combustible. Here we report the vehicles that use only internal combustion engines, without any support of any other different combustible or powertrain.

Diesel Engine

The Diesel engine was invented by Rudolf Diesel, who wanted to design an engine that could overcome the inefficiencies of steam engines. The main technological advance of the Diesel engine, that determines the difference with the gasoline engine, is the fact that there is no sparking in the cylinder to start the combustion. The combustion happens due to the compression of the volume due to the cylinder movement. The compression generates heat that *"acts as spark"* for the diesel fuel and starts the combustion, generating the gas expansion. The repetition of this cycle creates the movement of the cylinder and thefore the car can move[7].

This particular cycle provides to the diesel engine the ability to have a higher torque, compared with a gasoline one, therefore is practical for work application like tractor, high duty vehicles, maritime engines, locomotives etc.

[7]This is a semplification to understand main differences with the other engines.

Gasoline Engine

The gasoline engines uses the thermal cycle called Otto cycle. Was invented by his associates Gottlieb Daimler and Wilhelm Maybach[8]. The gasoline engine needs a spark in order to ignite the gasoline inside the combustion chamber and provoke the expansion of the chamber, the cylinder moves and therefore the automobile will move. The gasoline engine is largely used in sports cars, because can reach higher speeds compared to a diesel engine; in general produces less pollutants, especially less NO_X[9] due the different quality of the fuel.

Other fuels - LPG and Natural Gas

Natural Gas and LPG - Liquefied Petroleum Gas, are other 2 less common combustible for the automobiles. The fact that are less common is due the lower availability of LPG or Natural Gas stations[10]. These 2 fuels are commonly used in combination with gasoline or diesel, due the higher availability of fuel stations for the latter two.

The engine for these two different fuels are both diesel or gasoline, with some differences accordingly.

1.3.2 Electric vehicles and Hybrids

The raise of the electric engine increases the possibilities of the typology and powertrain's combinations of the vehicles sold by the car manufacturers. In order to make the electric transition more affordable and more accessible, automobiles were built with an electric engine and an ICE. This type of vehicles are called Hybrid, since are fueled both by electricity and combustible.

BEV - Battery Electric Vehicle

The BEV are automobiles fueled exclusively by electricity. They are equipped with batteries and electric engines. The number of electric changes according price and models. The presence of more than one engine is due the reduced size of the electric engine, that provides the possibility to have more than one to increase the power of the vehicle.

[8]Daimler founded together with Benz the Mercedes-Benz and Maybach is today a luxury division of Mercedes.

[9]NO_X is reffered to nitrogen oxides produced during the combustions. These are produces in larger quantities in Diesel engines than Gasoline engine.

[10]For the LPG, in Italy, is forbidden the self-service, limiting the availability of the fuel station according precise working hour. D.P.R n.340/2003

The sales of BEV are increasing, but limited by the price and the charge stations availability, that combined with recharging time, limit this type of vehicle to be not the first choice during the purchase process of a vehicle.

PHEV - Plug-in Hybrid Electric Vehicle

PHEV are equipped with a small battery and an electric engine that provided the possibility to have autonomy in small routes and help the engine during overpasses and during the start of the vehicle. In order to use the electric vehicle, the battery needs to be recharged.

HEV - Hybrid Electric Vehicle

HEV are equipped with a smaller electric engine than PHEV, that provides fewer kilometers range and lower speed to run in the electric only mode. Batteries are self charging through the ICE.

MHEV - Mild-Hybrid Electric Vehicle

MHEV are equipped with an electric engine and a small battery that is recharged only within the vehicle system, therefore through the regenerative break system. The electric engine do not allow the vehicle to run only in the electric mode, but support the vehicle during overtakes and during the start phase.

1.3.3 Segments

When the first automobile was made, the goal of it was simple: going from point A to point B in the fastest and safest[11] way possible. At the beginning cars were similar,2 or 4 doors, 5 or 6 seats, spacious and big to accommodate the passengers and the engine, that were big if compared with the one made today. During the years, the scope do not changed, but changed the requests of the customers: some people needed cars to carry materials, other to bring people, other small cars, other big, other cars that were able to go on the off-road, and so on. In this ways different models were made, to satisfy the different needs from the customers.

Today, in order to understand how to categorize the automobiles, were defined the segments[12].

[11] Safest for those time. Today standards are higher and cars safer

[12] Case No COMP/M.1406 Hyundai / Kia Regulation (EEC) No 4064/89 Merger Procedure

These segments do not divide precisely the automobiles, but gives an idea to the consumer of the car's characteristic that she is purchasing. Here is reported the list of the segments with a short description:

- A: mini cars
- B: small cars or city cars
- C: medium cars
- D: large cars
- E: executive cars
- F: luxury cars
- S: sport coupes
- M: multi purpose cars
- J: sport utility cars (including off-road vehicles)

There are not precise parameters to divide the cars in each segment, the paramaters used usually are: price, size, weight, number of doors and shape.

Chapter 2

The Automotive Market

Ferrari farà sempre un'auto in meno di quante ce ne chieda il mercato
Enzo Ferrari

The Automotive sector account for the 3% of the worldwide GDP[1]. The forecast is to reach 4.7 Trillion USD by 2030, confirming the importance of this market for the world economy. Some of the actors of this market are well known, like Volkswagen, Toyota, FIAT, Ford, General Motors, etc. others are less known, but critically important, like Bosch, Sumitomo, Marelli, LG, etc. that are mainly suppliers of the Auto-makers.

Currently the leading production country is China, producing more than 20 million vehicles per year, while some countries have seen a contraction of the automobile production like Italy, where in the first quarter there was a reduction of 35.5% compared to the one in the same quarter of the past year[2].

In the following section there will an excursus of the worlwide automotive market, focusing on some countries of interest due their history and due the automotive market size.

[1] Gitnux Report 2025 - Global Automotive Industry Statistics
[2] alVolante.it - Produzione auto in Italia: -35% nel 1^o trimestre 2025.

2.1 Worldwide overview of the automotive market

The automotive market is more fragmented than we usually think. A same brand sells different models, that are continents or country specific, in order to meet the taste of the specific market. A close example is FIAT, that sells models like Panda and Seicento, that are available only in the EMEA Enlarged market o like Scudo and Strada that are specific for the Brasilian and the South American Market.

In order to understand the global automotive market, for the moment, this differences will not be taken into account, the scope is to have a visual of the magnitude of the car sector and to appreciate the volumes, the revenues and the main actors that are the protagonist of such market.

2.1.1 Global Overview

Globally the automotive market has strong differences across country and continents, due different wages and different customer necessities.

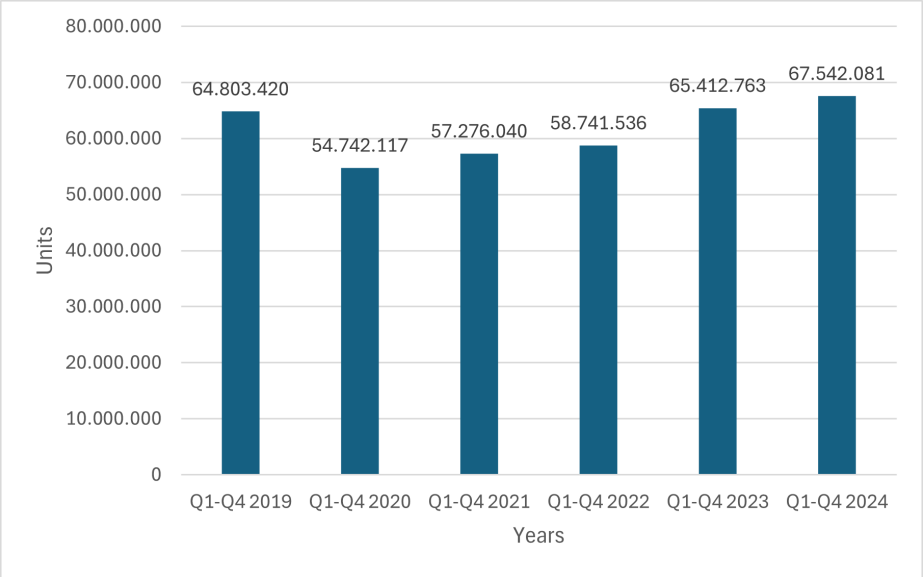

Figure 2.1: Global Sales for Passenger Vehicles 2019-2024

The graph[3] shows that the pandemic severely hitted the sales, with a decrease of 18% during 2020. Only after 3 years, in 2023, sales reached

[3]OICA Sales Data 2019-2024

the sames pre-Covid levels. Sales after the pandemic were affected by the semiconductor crysis[4], that affected the capacity of the OEM to meet the increase demand of cars after the end of the pandemic. In order to reduce the semiconductor needs, the OEM started the reduce their use to the bare minimum and use analog solution where those were suitable[5].

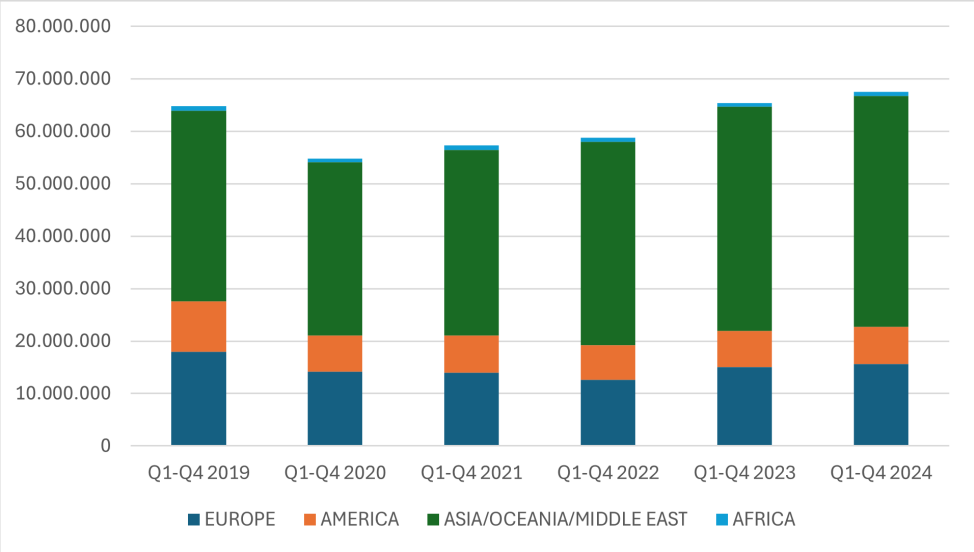

Figure 2.2: Global Sales per Continent 2019-2024

As expected the main sales of passenger vehicles is located in Asia. The continent counts for almost the 60% of the world population and the 65% of the global sales. In China is where the majority of the vehicles are sold, both in Asia and worldwide. China, in 2024, counted for the 40% of the global car sales, while the European Union[6] counts for 16% of global car sales. Is noticeable that China is the main vehicle market, but the brand with most sales in 2023 is Toyota, with a market share of 11%, while Japan counts for the 5.5% of the total global sales. This indicates that the China car market is fragmented, with many different car makers and not yet consolidated like the western car manifacturers. The oligopoly between car manifacturers

[4]The "Semiconductor Crisis" as a Result of the COVID-19 Pandemic and Impacts on the Automotive Industry and Its Supply Chains - Benjamin Frieske and Sylvia Stieler - October 2022

[5]McKinsey&Company - Semiconductor shortage: How the automotive industry can succeed by O.Burkacky, J.Deichmann, P.Pfingstag and J.Werra

[6]Counting EFTA members.

is much likely also in the Chinese market *"Considering the capital-intensive nature of automotive production line may lead to high barriers, as well as the high degree of specialisation arising from reasons of consumer safety, there are limited OEMs in the market, thereby making the market oligopolistic in nature and vulnerable to cartelisation."*[7]. Therefore is expected in the following years numerous of merge and acquisition between the different Chinese car makers in order to create big car makers group such Stellantis and Volkswagen.

2.1.2 Main Car Brands

As was previosly said, the car was invented in Europe and developed in the United States later on in the beginning of the 20^{th} century. After the Second World War, many brands started to rise and selling models that are still remembered today; like Volkswage, Toyota, Honda, FIAT and so on. In 2023 with a market share of 11% Toyota was the leading car brand with 8.5 millions cars sold, remaining leader for 4 years in a row.

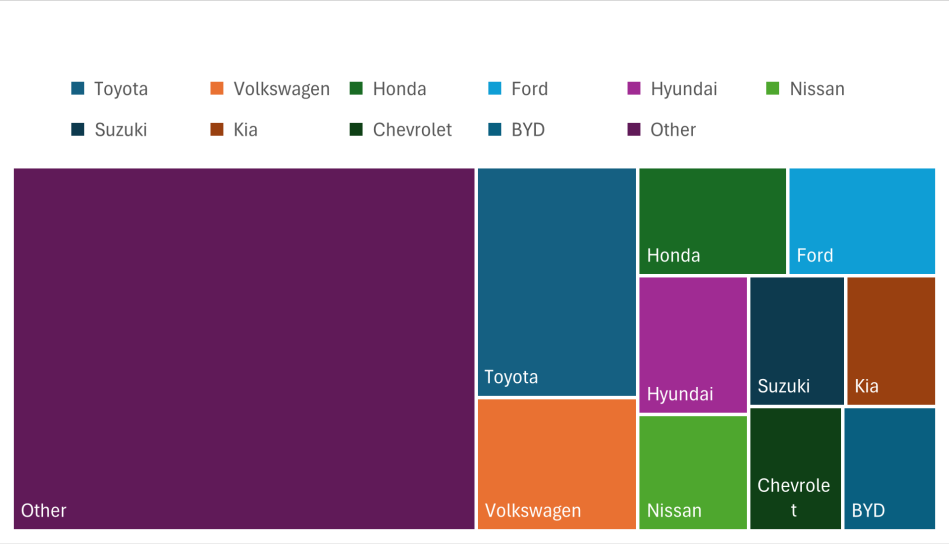

Figure 2.3: Sales per car Brand in 2023

As can be seen, the first 10 brands have almost the 50% of the market share, while all the other have the remaining 50%. The sales reported in

[7] A study on competition issues in the automotive sector - Report by the competition authorities of BRICS working group on automotive sector - 2021

the previous graph are related to the brand and not the group. For example Volkwagen is a car group with different brands like Audi, Lamborghini, etc. Stellantis has many brands, like FIAT, Alfa Romeo, Peugeout, etc.

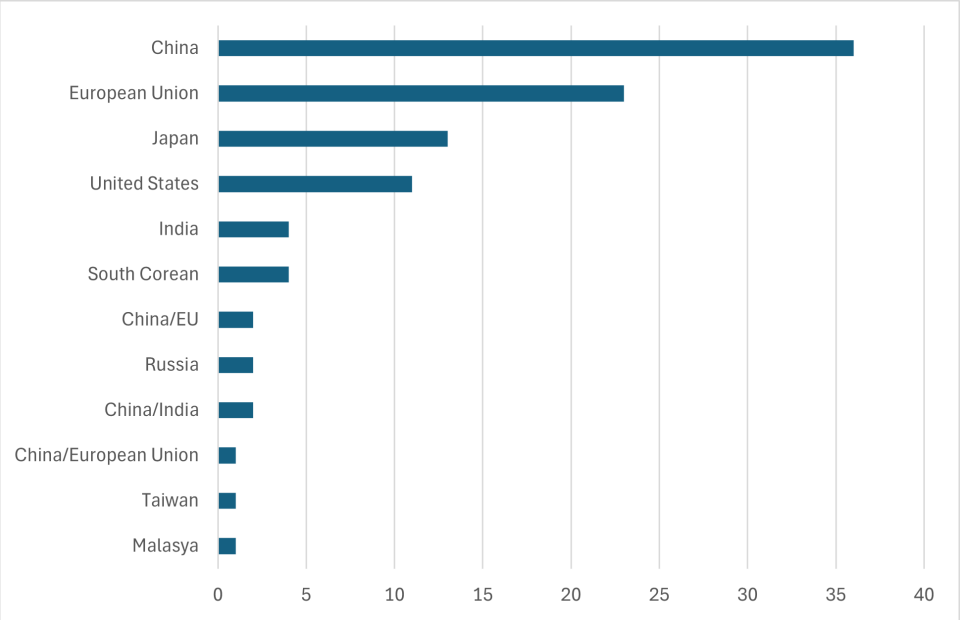

Figure 2.4: Car Brands per country

China leads the statistics with 36 different car brands, with more than 27 millions vehicle sold in 2024. Some brands are made with joint venture from groups from different places, like Leapmotors, joint venture between Leapmotor at 49% and Stellantis holding the 51%. For this reason, in these cases, this brands were considered from both contries, and reported in the specific section. The brands nationality was based on the ownership. For example Range Rover, well known 4x4 car brand, is considered Indian, because is owned by the Indian group TATA Motors, even if was born in United Kingdom and is a well established and recognized as British brand. Emergent markets like India and China star to buy well established brands like MG or Range Rover in order to penetrate the European and American market, reducing the market share of the already brands like Volkswagen and Stellantis.

2.1.3 Sales per Powertrain

Another aspect of a vehicle is its powertrain. During the last years, with the raise the BEV, the share of powertrain changed. The tecnology is continuously improving and new engines are developed.

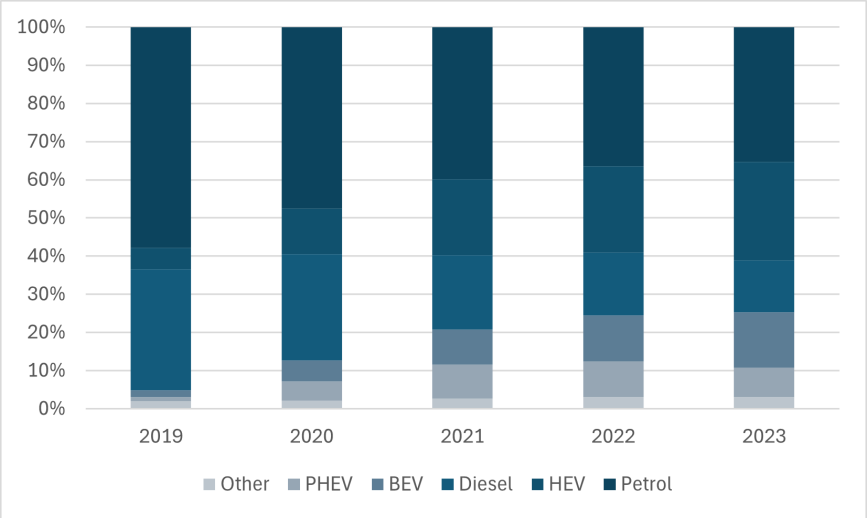

Figure 2.5: Fuel types of new passenger cars in EU 2019 - 2023

Looking at the graph[8], the share of the petrol and diesel cars is declining, going from 75% combined to less than 50% in 2023. BEV and MHEV are the one with the highest increase, while PHEV saw a strong increase in 2021, but a slight decline in 2023. The fact that BEV and MHEV are increasing strongly in the EU is due to the always more severe anti-pollution laws in the car sector and the increase in the offer of hybrid cars and BEV. During the last year european car manifacturers have been lobbying in order to obtain a change in the *European Green Deal*, to increase the flexibility in the car sector, in order to increase the car production in europe and boost the sales, claming that the climate ambitions would destroy the sector's competitiveness[9].

[8] ACEA - Fuel types of new passenger cars in EU

[9] Euronews - The European Green Deal and the car industry - a fight to the death? by Marta Pacheco - September 10, 2025

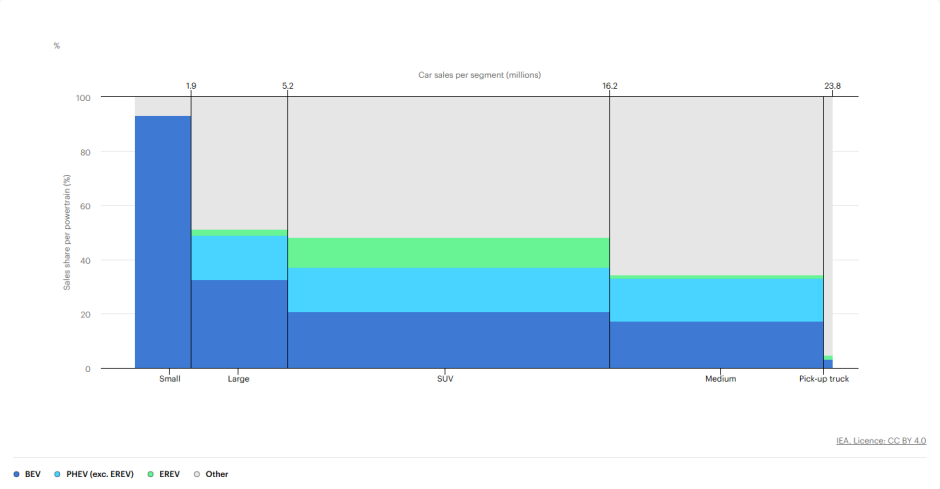

Figure 2.6: Total car sales in China per segment and powetrain 2024

Also in China, the biggest car market in the world, the share of the BEV is important, especially for the sector of small cars. Bigger the vehicle, smaller the share of the BEV, this is due to size, car's weight and load, since batteries reduces the load capacity of the vehicle, in heavy-duty application, the added weight of the batteries would make the vehicle not competitive in terms of costs, fuel efficiency and load capacity. The sector of the small cars instead is dominated by BEV. This is because the electric vehicle has a better efficiency in the city range, with low speeds[10]. Efficiency is also influenced by the external temperature, in a cold climate batteries capacity can drop, jeopardazing the battery life-span and the autonomy of the vehicle. Instead ICE are more efficients in the long ranges, at constants speed, like in the highway, making them preferable for the long distance travel, for this reason trucks have still Diesel engine and the BEV transition is particularly difficult for this application. For these reason, large and medium vehicles have mainly hybrid and ICE powertrains, while SUV have an important share of BEV vehicles, due the customers that are willing to pay more for a SUV that is also full electric.

[10] Auto Elettriche: la velocità è la prima nemica dell'autonomia - alVolante - by Andrea Spitti July 7 2025

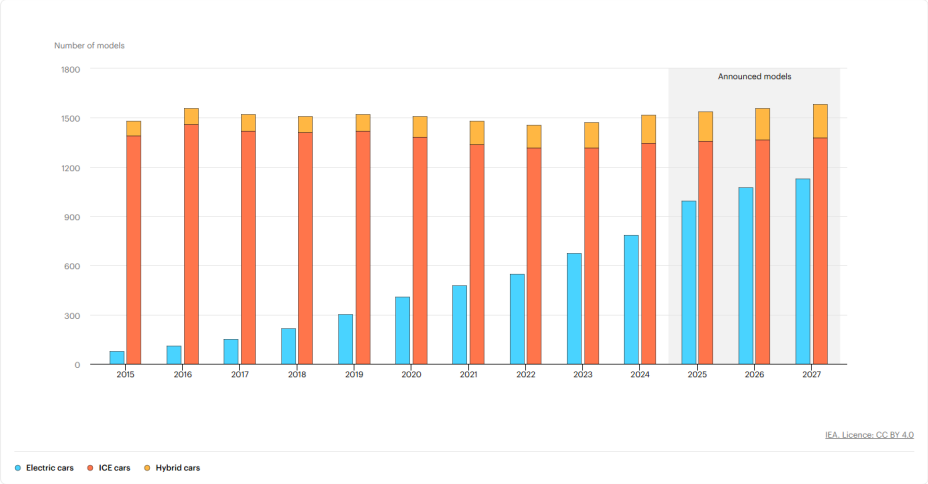

Figure 2.7: Car model availability by powertrain 2015-2027 (forecasted)

Is noticeable the increase of the BEV models. The graphs shows that car makers are offering mode models, with only a slightly reduction of the ICE model offer. This brings to the consumer a broader choice in the vehicles powertrain, promoting the transition to full-electric vehicles[11].

[11]For hybrid in this case is intended in PHEV MHEV or HEV, without distinction.

Chapter 3

The used car market

When consumers purchase a Toyota, they are not simply purchasing a car, truck or van. They are placing their trust in our company.
Akio Toyoda

The consumer not always chose to purchase a new car. The reasons can be vary, from the immediate need of a car, for a specific model that is not anymore produced or for budget constrain that do not allow to buy a new car. The market for used cars is growing, especially after COVID-19, where the price of the new cars have suffered an increase due inflation and semiconductor crisis. In order to find a good deal, both in purchasing or selling a car, many platforms are available on the internet, like: autoscout24, Subito, Facebook marketplace, etc. Those platform allow to the consumer to have an extent overview for models and segment, reducing the information gap between seller and buyer.

3.1 Used car market in numbers

The used car market continues to play a vital role in the automotive industry, reflecting shifting consumer preferences, economic trends, and evolving mobility needs. The used cars represents a market in continuos development, especially due the rise of the rent to buy/leasing options, that fuel the used market. The scope of this section is have an overview of such market, in order to understand the customer behaviour related to a car purchase.

3.1.1 U.S. used car market

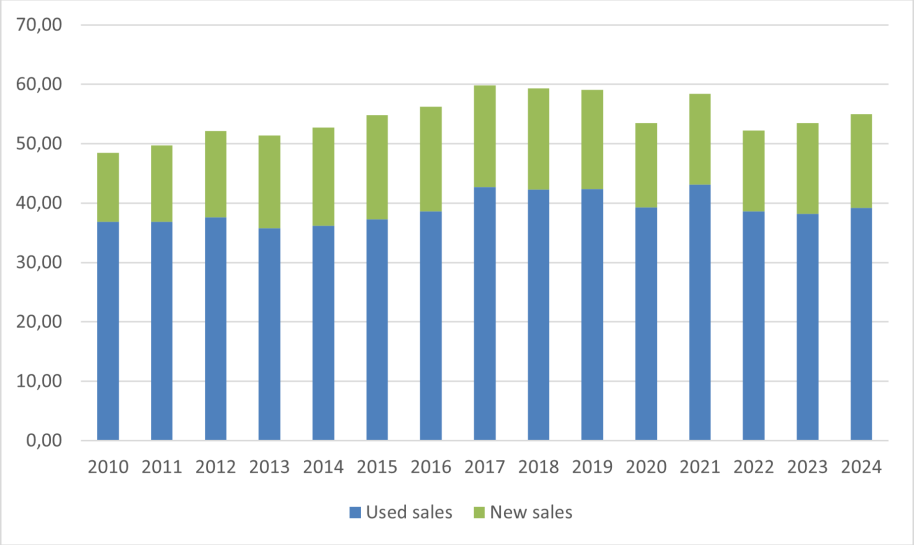

Figure 3.1: U.S. new vs. used light vehicles sales

As the graph shows, around 70% of vehicles[1] sold are used, indicating a pattern on the consumer to prefer to purchase an used vehicle instead of a new one. There is a slight decrease in 2020, probably due the pandemic, that affected every market and since the availability of new vehicles was impacted, the offer of used vehicles as been affected too.

3.1.2 Europe used car market

According data available, is important to try to catch differences according the heterogeneous markets inside Europe. For this reason were taken data

[1]Experian Changes in US vehicles in Operation - Light duty vehicles - April 2025

from the following countries: Spain, Belgium, UK[2], France, Germany.

Spain

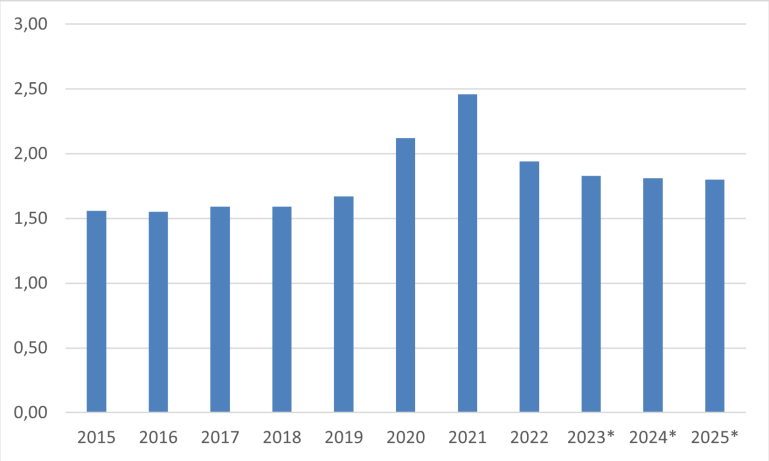

Figure 3.2: Ratio of second-hand cars to new cars in Spain

Belgium

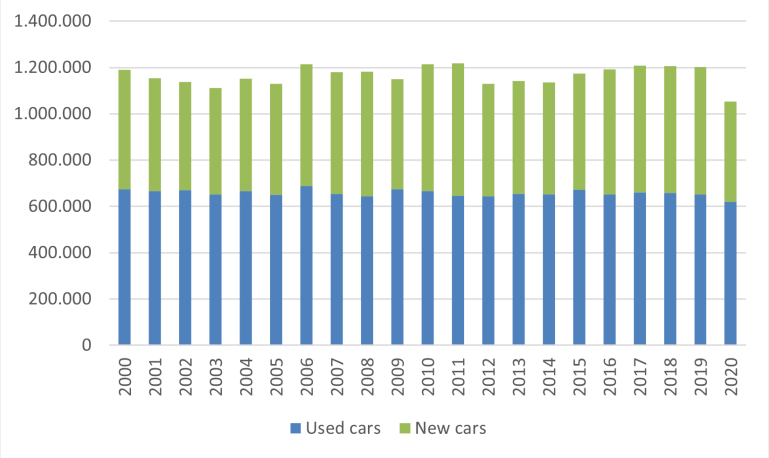

Figure 3.3: Number of used and new cars sold in Belgium

[2]Even if it is not in the EU, Uk is a European country, and the interest is to understand consumer behaviour related to the used car market.

United Kingdom

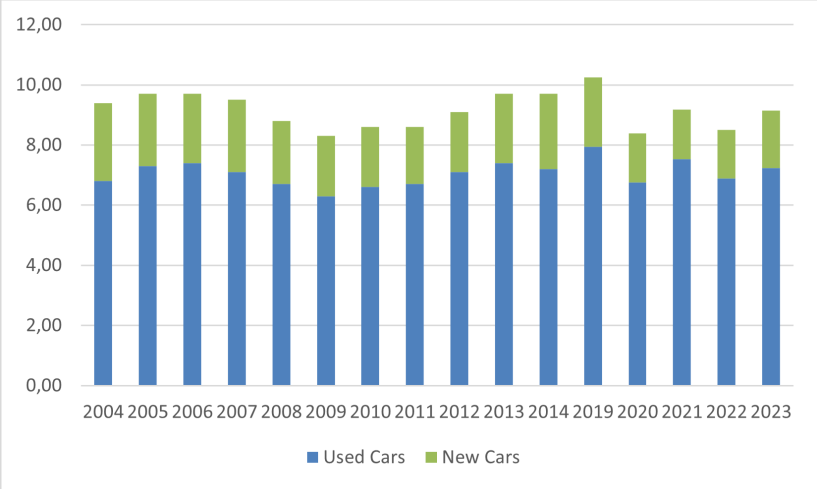

Figure 3.4: New and used car sales in the United Kingdom

France

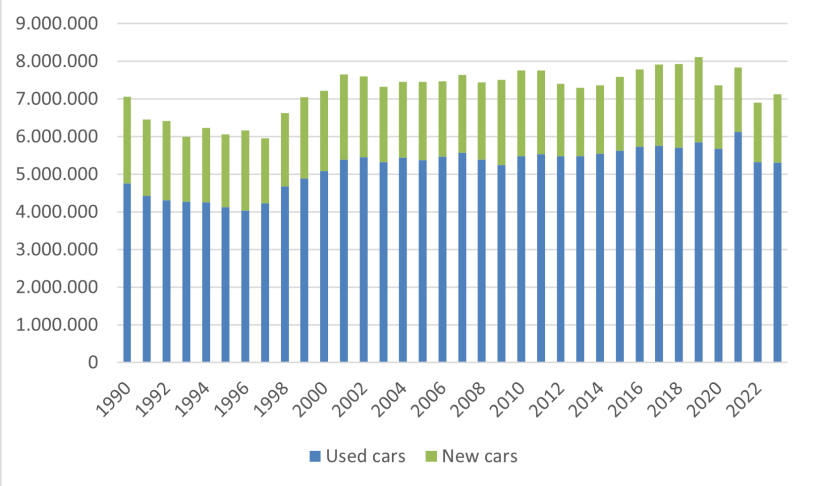

Figure 3.5: Number of used and new cars sold in Belgium

Germany

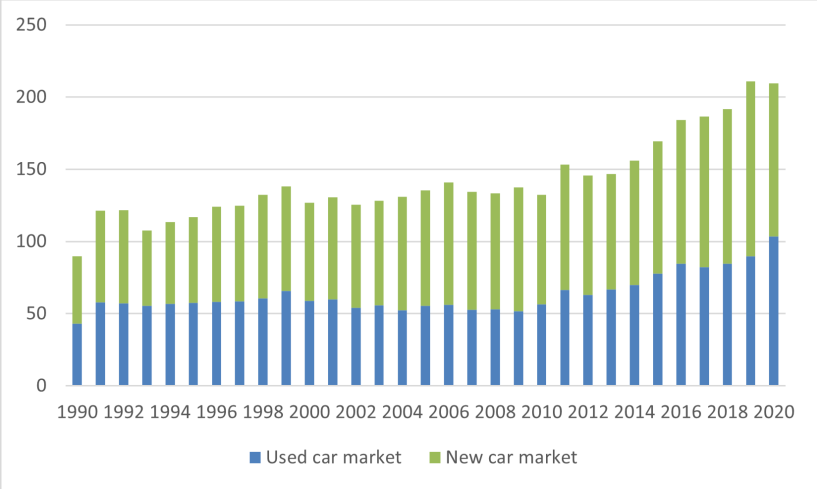

Figure 3.6: Revenue of the used and new car markets in Germany, in billion euros

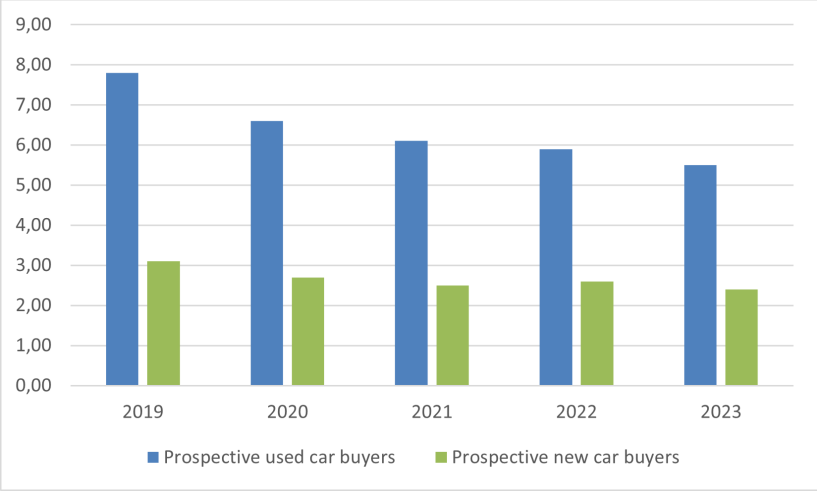

Figure 3.7: Share of consumers in Germany who considered purchasing a new or used car in the next one to two years

From the data showed, the used car market is a thriving market, selling more vehicles, and with a size similar to the new vehicle market. It's interesting the Germany case, in which is clear the increase in sales of new car, to

which corrisponded a decrease in sales of used cars on the long period. The exception constituted the year 2020 with a jump; this can be explained by the pandemic, due a scarsity of new vehicles and therefore the consumer was forced to shift to buy used vehicles. After 2020, as showed in the figure 3.7, the people willing to buy a vehicle reduces over time, and is always higher the people willing to buy an used vehicle than a new one, confirming the importance of such market.

Chapter 4

Dataset

In God we trust. All others must bring data
W. Edwards Deming

In order to understand the used car market, the goal is to understand how vehicles depreciate over time. In order to do so, was retrieved a public use dataset, from autoscout24, a famous and well-established website, used to sell used or new vehicles. The platform has customers from all over Europe and U.S.; in this particular case we focused on a subset of vehicles from 2011 to 2023 in the German market. The dataset was presented with 9 variables and with 46.405 istances, from different car makers and models.

4.1 Dataset description

The dataset was retrived by public domain dataset in Kaggle. The collection methodology is by *scraping listing*, from the website *autoscout24.com*. The information specifically retrieved are:

- Mileage
- Maker
- Model
- Fuel type
- Gear type
- Offer type
- Sales price
- Horse power
- Year (of registration)

For different car makers and models, from 2011 to 2023. The overall dataset presents the following characteristics:

Observation	46.405
Variables	9
Size	4.826.120

The variables that identify the vehicles are: maker, model, fuel type and gear type; for example there can be a maker:FIAT, model:500, fuel type: Gasoline, gear type: manual. For each FIAT 500, gasoline and manual the dataset can have different offer type, with different sales price and horse power. The difference in horse power is due the different setup a FIAT 500 can be bought. This is difficult to appreciate in this dataset, since can be estimated only through the horse power, but there are setup that have the same powertrain, but changes the dressing, for example currently is possible to buy the FIAT 500 electric with two different dressing[1]. From this dataset this will not be appreciated, therefore was not taken into account, since this interest only a few models.

[1] fiat.it - 500 elettrica

4.2 Dataset Analysis

The dataset was analyzed with the software STATA, version 16.0. From the dataset the goal is to retrieve other information regarded the actual new prices of the models that are part of the dataset of use and are statistically significant. In order to do so:

$$tabmake, sort$$

$$keep\ if\ make == "Volkswagen" | \ ... \ | make == "Kia"$$

The dataset is sorted by the makers frequency. In this way are choosen the makers wih most observation which are:

- Volkswagen
- Opel
- Ford
- Skoda
- Renault
- Audi
- BMW
- Mercedes-Benz
- SEAT
- Hyundai
- FIAT
- Toyota
- Peugeout
- Kia

Then a sorting through the model values is done:

$$egen \;\; numero\_mod{=}count(model), \; by(model)$$

$$keep \; if \; numero\_mod > 100 \; \& \; numero\_mod! = .$$

Is generated a new variable that counts the number of occurrance of the models, that are non-null, and then restrict the dataset to those who have 100 or more occurrance; this is done in order to maintain a statistically relevance during the analysis.

The dataset obtained from this operation is the following:

Observation	30.677
Variables	10
Size	3.313.116

Now, in order to have a list of unique elements for which do the research for the original price, it's essential to retrieve the unique values for the combination of maker, model, fuel type and gear. These are the unique identificator for a give car. For each combination it is possible to have different mileaged, offer type, sales price, horse power and year of registration.

$$egen \; numero\_modello = group(make \; model \; fuel \; gear)$$

These generate 88 missing values, which had gear as a null values. These istances were eliminated since every vehicle as to have a gear type, which is automatic or manual.

Variable	Obs	Mean	Std. Dev.	Min	Max
numero_mod	30.589	264.6565	145.77779	1	496

There are 496 of unique combinations. These are the models of our dataset, based on these, were found the *actual purchase price*. The collection methology was manual scrapping on the maker website, considering the fuel and gear type currently available[2]. The merge done was *m to 1*, since the 496 values obtained were unique and had to merged with the complete

[2]Some models were not available with Diesel powertrain, due the Green New Deal, with more stringent parameters for the car makers.

dataset. After the merge of the new prices, for which was created the variable *PREZZO NEW*, that is the actual price for that maker, model gear type and fuel type specifically. Here reported are the descriptive statistics of the dataset for price and prezzo new.

PREZZO NEW

	Percentiles	Smallest		
1%	16490	16490		
5%	18450	16490		
10%	20300	16490	Obs	15,659
25%	22890	16490	Sum of Wgt	15,659
50%	32100		mean	33790.2
		Largest	Std. Dev	12218.94
75%	39790	78955		
90%	52170	82395	Variance	1.49e+08
95%	61600	82395	Skewness	.9103415
99%	64139	82395	Kurtosis	3.388448

price

	Percentiles	Smallest		
1%	3555	1300		
5%	4980	1396		
10%	5950	1500	Obs	15,659
25%	7990	1500	Sum of Wgt	15,659
50%	1200		mean	15720.75
		Largest	Std. Dev	10323.06
75%	19490	98825		
90%	28990	99333	Variance	1.07e+08
95%	35450	99940	Skewness	1.953009
99%	49490	101880	Kurtosis	9.308044

Now we can generate the depreciation variable, defined as:

$$gen\ depreciation = prezzo\_new\ -\ price$$

In order to control the data, a sum of the depreciation is done, with the following results:

depreciation

	Percentiles	Smallest		
1%	-2.330	-36.260		
5%	4.205	-26.855		
10%	6.565	-26.290	Obs	15.659
25%	11.440	-24.915	Sum of Wgt	15.656
50%	17350		Mean	18489,44
		Largest	Std. Dev.	10223,9
75%	24.520	57.319		
90%	31.416	58.369	Variance	1,05e+08
95%	37.010	58.505	Skweness	0,4866252
99%	47.805	61.525	Kurtosis	3,815199

Can be noticed that there are some negative values, meaning that the actual purchase price is lower than the re-sell price. This is due the different configurations in the high value models, for which is difficult to determine the correct purchase price due the different options available. In order to have a percentage variation and to eliminate the negative depreciation:

$$log\_dep = log(depreciation)$$

$$keep\, if\, log\_dep > 0 \,\&\, ! = .$$

Doing so, 15.183 observations are deleted. Since the models that have the fuel tipe hybrid with ICE diesel are only 3, these observations are deleted too, since will not be meaningfull in the analysis. The dataset obtained is the following one:

Observation	15.404
Variables	13
Size	1.925.500

After are created the dummy variables and changed the mileage in a new variable:

$$mileage\_2 = \frac{mileage}{10.000}$$

This is done in order to have higher coefficient values in order to do a better analysis. The descriptive statistics are the following:

Variable	Obs	Mean	Std. Dev	Min	Max
mileage	15,404	68600.63	62719.97	0	620000
mileage_2	15,404	6.860063	6.271997	0	62

Then the dummy variable for each year are generated:

$$tab\, year,\ gen(year\_dum)$$

year	Freq.	Percent	Cum.
2011	1,259	8.17	8.17
2012	1,297	8.42	16.59
2013	1,361	8.84	25.43
2014	1,336	8.67	34.10
2015	1,260	8.18	42.28
2016	1,332	8.65	50.93
2017	1,437	9.33	60.26
2018	1,427	9.26	69.52
2019	1,363	8.85	78.37
2020	1,704	11.06	89.43
2021	1,628	10.57	100.00
Total	15,404	100.00	

Generation of dummy variables for different powertrain (fuel type):

$$tab\, fuel,\ gen(fuel\_dum)$$

fuel	Freq.	Percent	Cum.
Diesel	4,437	28.80	28.80
Electric	23	0.15	28.95
Electric/Gasoline	391	2.54	31.49
Gasoline	10,553	68.51	100.00
Total	15,404	100.00	

Generation of dummy variable for the car maker:

$$tab\, make,\ gen(make\_dum)$$

make	Freq.	Percent	Cum.
Audi	1,299	8.43	8.43
BMW	689	4.47	12.91
Fiat	782	5.08	17.98
Ford	1,057	6.86	24.84
Hyundai	1,232	8.00	32.84
Kia	478	3.10	35.95
Mercedes-Benz	663	4.30	40.25
Opel	1,730	11.23	51.48
Peugeot	143	0.93	52.41
Renault	754	4.89	57.30
SEAT	1,249	8.11	65.41
Skoda	1,696	11.01	76.42
Toyota	84	0.55	76.97
Volkswagen	3,548	23.03	100.00
Total	15,404	100.00	

The previously table report the data about the unique identificator of a record. These will be used for the next analysis and will be the data used to determine the entity of the impact on the depreciation for the used cars.

Chapter 5

Analysis of the variables

5.1 Mileage

The impact on the depreciation using only the mileage is here reported:

Source	SS	df	MS	Number of obs	=	15,404
				F(1, 15402)	=	11357.74
Model	2679.48799	1	2679.48799	Prob > F	=	0.0000
Residual	3633.59972	15,402	.235917395	R-squared	=	0.4244
				Adj R-squared	=	0.4244
Total	6313.08771	15,403	.409860917	Root MSE	=	.48571

log_dep	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
mileage_2	.0664994	.000624	106.57	0.000	.0652763	.0677224
_cons	9.225761	.0057999	1590.69	0.000	9.214393	9.23713

The coefficient is 0.0664994, meaning that every 10.000 km, the vehicles looses 6.65% of its value, or the depreciation increased of the 6.65%. This is a reasonable value, but alone cannot explain the depreciation of the vehicle, since a car with 0km, but with 10 years can not have the same price as new. Due the values of t and P, this is a highly significal coefficient.

5.2 Mileage and age

In order to have an idea of the age, we take as reference year the 2011 and analyze how the depreciation changes according chilometers and age.

Source	SS	df	MS	Number of obs	=	15,404
				F(11, 15392)	=	1712.38
Model	3474.16528	11	315.833207	Prob > F	=	0.0000
Residual	2838.92243	15,392	.184441426	R-squared	=	0.5503
				Adj R-squared	=	0.5500
Total	6313.08771	15,403	.409860917	Root MSE	=	.42947

log_dep	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
mileage_2	.0395472	.0007659	51.64	0.000	.0380459	.0410484
year_dum2	.0048433	.0169987	0.28	0.776	-.028476	.0381627
year_dum3	.0302517	.0168615	1.79	0.073	-.0027989	.0633023
year_dum4	-.0196529	.017035	-1.15	0.249	-.0530436	.0137378
year_dum5	-.0377586	.0173459	-2.18	0.030	-.0717586	-.0037585
year_dum6	-.0369552	.0173134	-2.13	0.033	-.0708914	-.003019
year_dum7	-.0010163	.0172022	-0.06	0.953	-.0347348	.0327021
year_dum8	-.0705662	.017472	-4.04	0.000	-.1048134	-.0363191
year_dum9	-.2586718	.0186366	-13.88	0.000	-.2952017	-.2221418
year_dum10	-.5258417	.0184103	-28.56	0.000	-.561928	-.4897554
year_dum11	-.8483306	.0188929	-44.90	0.000	-.8853628	-.8112984
_cons	9.592909	.0156394	613.38	0.000	9.562254	9.623565

The mileage effect remains significant with a coefficient of 0.0395472. Taking as reference year 2011, the depreciation is positive affected by the years 2012 and 2013. Then since 2014 to 2021, the depreciation is reduced as the year increases. Noticeable are the years from 2012 to 2017 that due the high value p, the null hypothesis cannot be rejected and therefore the variables can not influence the depreciation.

5.3 Mileage, age and fuel type

Now the variables considered are mileage, age, with the reference year 2011 and fuel type, with reference fuel type of gasoline, fuel_dum4.

Source	SS	df	MS	Number of obs	=	15,404
				F(14, 15389)	=	1666.40
Model	3803.90449	14	271.707464	Prob > F	=	0.0000
Residual	2509.18322	15,389	.16305044	R-squared	=	0.6025
				Adj R-squared	=	0.6022
Total	6313.08771	15,403	.409860917	Root MSE	=	.4038

log_dep	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
mileage_2	.0207519	.0008338	24.89	0.000	.0191175	.0223862
year_dum2	-.0263445	.015998	-1.65	0.100	-.0577025	.0050135
year_dum3	-.0294258	.0159122	-1.85	0.064	-.0606156	.001764
year_dum4	-.0900723	.016095	-5.60	0.000	-.1216205	-.0585241
year_dum5	-.1338567	.016453	-8.14	0.000	-.1661066	-.1016069
year_dum6	-.1685068	.0165462	-10.18	0.000	-.2009393	-.1360744
year_dum7	-.1764945	.0166466	-10.60	0.000	-.2091239	-.1438652
year_dum8	-.2622941	.0169825	-15.44	0.000	-.2955818	-.2290065
year_dum9	-.462562	.0181087	-25.54	0.000	-.4980572	-.4270668
year_dum10	-.731887	.0179732	-40.72	0.000	-.7671166	-.6966575
year_dum11	-1.012783	.0183136	-55.30	0.000	-1.04868	-.9768861
fuel_dum1	.3814003	.0085442	44.64	0.000	.3646527	.3981479
fuel_dum2	-.3875282	.0846836	-4.58	0.000	-.5535181	-.2215383
fuel_dum3	.0135197	.0211739	0.64	0.523	-.0279836	.055023
_cons	9.73781	.0150573	646.72	0.000	9.708296	9.767324

As expected the mileage as a positive impact on the depreciation. Besides year_dum2 and year_dum3, with high t values, all the other years have a negative connotation on the depreciation, reducing it, with the time passes by. It can be explained since year are growing, therefore the vehicle is less old and thefore the depreciation is less. Interesting that the fact that a vehicle is electric, reduces the depreciation. This can be explained by the fact that electric vehicles are younger in general, and therefore the depreciation is less strong. In order to have better data the sample of electric vehicles should be higher.

5.4 Mileage per fuel type, age, fuel type

For this particular case the analysis is done with the interaction between mileage and propulsion type:

$$mileage\_2\_dies = mileage\_2 \cdot fuel\_dum1$$

$$mileage\_2\_elec = mileage\_2 \cdot fuel\_dum2$$

$$mileage\_2\_el\_be = mileage\_2 \cdot fuel\_dum3$$

$$mileage\_2\_benz = mileage\_2 \cdot fuel\_dum4$$

Given the year 2011 as reference year, and gasoline as reference fuel, the coefficient computation is the following:

Source	SS	df	MS	Number of obs	=	15,404
				F(17, 15386)	=	1375.77
Model	3807.98274	17	223.998985	Prob > F	=	0.0000
Residual	2505.10497	15,386	.16281717	R-squared	=	0.6032
				Adj R-squared	=	0.6028
Total	6313.08771	15,403	.409860917	Root MSE	=	.40351

log_dep	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
mileage_2_dies	.019302	.000885	21.81	0.000	.0175673	.0210367
mileage_2_elec	.125192	.1322065	0.95	0.344	-.1339485	.3843324
mileage_2_el_be	.0308112	.0072382	4.26	0.000	.0166235	.0449988
mileage_2_benz	.0257216	.0013199	19.49	0.000	.0231345	.0283087
year_dum2	-.0217569	.0160175	-1.36	0.174	-.0531531	.0096393
year_dum3	-.0211743	.0160121	-1.32	0.186	-.0525599	.0102113
year_dum4	-.0791264	.0162494	-4.87	0.000	-.1109772	-.0472756
year_dum5	-.1195491	.0167335	-7.14	0.000	-.1523488	-.0867494
year_dum6	-.1514541	.0169231	-8.95	0.000	-.1846255	-.1182828
year_dum7	-.1583845	.0170632	-9.28	0.000	-.1918303	-.1249387
year_dum8	-.2423665	.0174742	-13.87	0.000	-.276618	-.2081151
year_dum9	-.4347678	.0189854	-22.90	0.000	-.4719815	-.3975541
year_dum10	-.6982942	.0192111	-36.35	0.000	-.7359503	-.6606381
year_dum11	-.9696184	.0202571	-47.87	0.000	-1.009325	-.9299122
fuel_dum1	.4268406	.0126327	33.79	0.000	.4020792	.4516021
fuel_dum2	-.4118532	.0922795	-4.46	0.000	-.5927321	-.2309744
fuel_dum3	.008511	.0251037	0.34	0.735	-.0406953	.0577173
_cons	9.692151	.0177379	546.41	0.000	9.657383	9.72692

The chilometers impacts moe in a PHEV (mileage_2_el_be), due the fact that not only there is the wear of the engine, but also of the battery. Instead, as expected, the diesel vehicles are the less impacted, since diesel engines are build up to run several chilometers, before to wear out. The BEV are positioned better than PHEV and gasoline engine, this can be due the fact that the observation are scarce and also because BEV are relative young cars, compared to the gasoline ones.

The hypothesis test that there is no difference between different engines is performed:

$$mileage\_2\_dies - mileage\_2\_benz = 0$$

The test's results are:

```
 ( 1)  mileage_2_dies - mileage_2_benz = 0

       F(  1, 15386) =   23.59
            Prob > F =    0.0000

. test mileage_2_el_be=mileage_2_benz

 ( 1)  mileage_2_el_be - mileage_2_benz = 0

       F(  1, 15386) =    0.50
            Prob > F =    0.4783
```

The null hypothsis can be rejected between diesel and gasoline engine. The same cannot be said between Gasoline PHEV and Gasoline, for which the nulla hypothesis cannot be rejected. This makes sense because the owners of PHEV vehicles are used to not recharge the vehicles[1], forcing the car makers to impose the recharge of the PHEV reducing the horse power available by the vehicle. Making in this way PHEV like normal gasoline vehicle with just an added battery.

5.5 Mileage per fuel type, age, fuel type and car maker

Now the variables considered are mileage per fuel type, age, with the reference year 2011, fuel type, with reference fuel type of gasoline, fuel_dum4 and car maker, with reference "Mercedes-Benz".

[1] alVolante - Ricarica obbligatoria per le auto plug-in

Source	SS	df	MS	Number of obs	=	15,404
				F(30, 15373)	=	1123.71
Model	4335.85627	30	144.528542	Prob > F	=	0.0000
Residual	1977.23144	15,373	.128617149	R-squared	=	0.6868
				Adj R-squared	=	0.6862
Total	6313.08771	15,403	.409860917	Root MSE	=	.35863

log_dep	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
mileage_2_dies	.0159382	.0007922	20.12	0.000	.0143854	.017491
mileage_2_elec	.1537419	.1176203	1.31	0.191	-.0768078	.3842916
mileage_2_el_be	.0515878	.0081317	6.34	0.000	.0356486	.0675269
mileage_2_benz	.0189599	.0011893	15.94	0.000	.0166288	.021291
year_dum2	-.0221243	.01425	-1.55	0.121	-.050056	.0058073
year_dum3	-.0396285	.0142487	-2.78	0.005	-.0675577	-.0116993
year_dum4	-.0869067	.0144601	-6.01	0.000	-.1152502	-.0585633
year_dum5	-.1233816	.0148977	-8.28	0.000	-.1525829	-.0941803
year_dum6	-.1406534	.0150753	-9.33	0.000	-.1702028	-.111104
year_dum7	-.1759233	.0152026	-11.57	0.000	-.2057221	-.1461245
year_dum8	-.2672992	.0155984	-17.14	0.000	-.2978738	-.2367245
year_dum9	-.4671425	.0169298	-27.59	0.000	-.5003269	-.4339581
year_dum10	-.7653478	.0172677	-44.32	0.000	-.7991945	-.731501
year_dum11	-.9520947	.0181154	-52.56	0.000	-.987603	-.9165863
fuel_dum1	.2987281	.0118893	25.13	0.000	.2754237	.3220324
fuel_dum2	-.4437777	.0824615	-5.38	0.000	-.6054121	-.2821434
fuel_dum3	.0145555	.0232493	0.63	0.531	-.0310159	.060127
make_dum1	-.4410952	.0172547	-25.56	0.000	-.4749165	-.4072739
make_dum2	-.0065441	.0195944	-0.33	0.738	-.0449515	.0318632
make_dum3	-.4936933	.0200168	-24.66	0.000	-.5329286	-.454458
make_dum4	-.2427032	.0181726	-13.36	0.000	-.2783237	-.2070827
make_dum5	-.5882743	.0180404	-32.61	0.000	-.6236356	-.552913
make_dum6	-.5933551	.0220752	-26.88	0.000	-.6366251	-.5500851
make_dum8	-.4505213	.0170543	-26.42	0.000	-.4839498	-.4170928
make_dum9	-.2414405	.0333377	-7.24	0.000	-.3067864	-.1760945
make_dum10	-.7740462	.0196115	-39.47	0.000	-.8124871	-.7356054
make_dum11	-.2536414	.0177374	-14.30	0.000	-.2884088	-.218874
make_dum12	-.5205167	.016679	-31.21	0.000	-.5532095	-.4878239
make_dum13	-.7513238	.0583513	-12.88	0.000	-.8656992	-.6369484
make_dum14	-.2020256	.0153144	-13.19	0.000	-.2320437	-.1720075
_cons	10.14115	.0217038	467.25	0.000	10.09861	10.18369

First impact is that all the car makers have a negative impact on the depreciation, meaning that Mercedes-Benz depreciates more than the other car brands. The reasons behind this phenomena can be due the fact that Mercedes-Benz lose their value intrinsecaly, meaning that besides being a luxury car, the "entry-level" Mercedes-Benz do not hold much value after they are purchased. All years affect negatively the depreciation, that can be explained because are all higher years than 2011, therefore the vehicles

are newer. Now is important to understand if the mileages per fuel type do create difference, or the engine type is not influence at all by the mileage.

```
( 1)  mileage_2_dies - mileage_2_benz = 0

      F(  1, 15373) =    6.50
           Prob > F =    0.0108

. test mileage_2_el_be=mileage_2_benz

( 1)  mileage_2_el_be - mileage_2_benz = 0

      F(  1, 15373) =   16.20
           Prob > F =    0.0001
```

As expected the mileage per fuel type, in both cases, reject the null hypothesis, since each engine reacts differently according the mileage covered. Gasoline engines are not made to travel a significant amount of chilometers, while the electric vehicles have the batteries that wears out with the recharge cycles more than the chilometers and the two are not strictly connected. Diesel engine however are built for long travels and can be active for more chilometers than the gasoline engines. Therefore the empirical reality confirms the statistical results here reported.

Chapter 6

Conclusions

The analysis of the dataset gave results similar to what the general public use to say regards the effect of the depreciation of used vehicles. There is no surprise in the fact that the test consider diesel and gasoline very different between one another. Looking at the dataset, the majority of the vehicles are with a gasoline powertrain, with 10,553, against the 4,437 of Diesels. This can reflects a preference on the consumer to purchase gasoline cars. This difference is underlined also when are considered the mileage per fuel tipe. In the latter mileages have an important role, since Diesel engine are preferred on long distances and therefore travel through more kilometers than gasoline engines[1]. Noticeable that in the case the car maker is not considered, the null hypothesis over mileage per fuel type PHEV (Gasoline) and mileage per fuel type full gasoline can not be rejected. Instead the null hypothesis is rejected when the variable car maker is introduced. This can be explained because without considering the car maker, the behaviour of the PHEV and gasoline is very similar. This similar behaviour between PHEV and Gasoline is not far from reality. As previously mentioned, when the PHEV were launched the owners do not use to recharge the vehicle, using it like a normal gasoline vehicle. Once the variable car maker is introduced, within the car makers, differences between PHEV and Gasoline in mileage per fuel type arise. This can be explained that within the same car maker, there is an actual difference in the mileage according the fuel type, meaning that the customer base is different for the two different fuel type and miles travelled. The effect of the depreciation are noticeable, indeed for these variable the coefficients are from 0.019 to 0.051, having an impact from 1.9%

[1]Trucks engines, in example, are dominated by the use of the Diesel cicle. This is due the high performance over long distance with constant speed, like the highway

to 5.1% according mileage and fuel type considered.

The vehicle age coefficient are almost all negative. This can be explained due the fact that as a reference point was take the year 2011. Since the coefficient of dummy can be defined as:

Coefficient of dummmy = Mean of that group - Mean of reference group

Changing the reference group will change also the coefficients. Using the reference year 2011, will give cars with lower prices due the age, therefore is correct to have negative coeffiecient, because as the years increases, the depreciation is less severe. When were considered only mileage and age, the years 2012, 2014 and 2017 appears to be not significant. 2012, so just one year after the baseline, can be not significant meaning that after 1 year the age does not affect severely the vehicle depreciation and most of the depreciation is to attribute to the mileage. This consideration is valid for all others tests performed, meaning that other variables affect the depreciation of a vehicle just after one year. Those variables can be others of the one considered in this thesis, like engine with several issue, new model, etc.

Analyzing the fuel type, PHEV and Diesel have an expected behaviour to increase the depreciation, with the Diesel that impacts it more than PHEV. BEV vehicles have a strange behaviour on the depreciation, since instead of increase it, reduced. The sample was only about 23 vehicles, therefore a specific study is needed with more data in order to asses if this statement is true, because would mean that a BEV will compensate the year and maker effect. The Diesel depreciation impacts more, related only with the fuel type, probably for the customer behaviour to not buy Diesel vehicles, therefore the fact that the vehicle has a diesel powertrain will automatically increase the depreciation.

Introducing the maker, with reference maker Mercedes-Benz shows that all the other makers decrease the depreciation, meaning that the fact owning a Mercedes-Benz will increase the depreciation automatically. Investigate in this matter is needed interviews and a deep analysis of a broader sample of vehicles in order to understand the effect on the maker, that is strictly related to the quality of the model per se.

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