# PRICING OF USED CARS IN UKRAINE: LOOKING INTO MORE THAN 100,000 DEALS IN THE AUTOMOTIVE AFTERMARKET.

by

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# TABLE OF CONTENTS

LIST OF FIGURES ..... ii
LIST OF TABLES ..... iii
LIST OF ABBREVIATIONS ..... iv
CHAPTER 1. INTRODUCTION ..... 1
CHAPTER 2. INDUSTRY OVERVIEW AND RELATED STUDIES ..... 3
2.1. Analysis of online platforms for buying and selling used car ..... 3
2.2. Main trends in the used car market of Ukraine for 2018-2021 ..... 7
2.3. Related studies ..... 20
CHAPTER 3. METHODOLOGY ..... 25
CHAPTER 4. DATA ..... 29
4.1. Source of data ..... 29
4.2. Data cleaning ..... 29
4.3. Data description ..... 31
CHAPTER 5. RESULTS ..... 36
5.1. First model ..... 36
5.2. Second model ..... 37
5.3. Third model ..... 38
CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS ..... 40
REFERENCES ..... 42

# LIST OF FIGURES


| *Number* | *Page* |
|---|---|
| Figure 1. The distribution of operations with used car by year | 8 |
| Figure 2.Top 20 the most popular brands 2018-2021 | 9 |
| Figure 3. The most popular brands by region (Abroad 2018 – 2021) | 10 |
| Figure 4. The distribution of quantity of Abroad operations by region (2018 – 2021) | 12 |
| Figure 5. The distribution of the most popular brands by region (Ukrainian transactions 2018 – 2021) | 13 |
| Figure 6. Cars' age by Origin 2018-2021 | 14 |
| Figure 7. Cars' age by body 2018-2021 | 15 |
| Figure 8. Top 20 the most popular models 2018-2021 | 16 |
| Figure 9. The distribution of electric cars by region 2018-2021 | 18 |
| Figure 10. The distribution of cars by colors 2018-2021 | 19 |
| Figure 11. Distribution of residuals for three models | 28 |

# LIST OF TABLES


| *Number* | *Page* |
|---|---|
| Table 1. Statistics of the most popular auto platforms in Ukraine (as of 09.2021) | 3 |
| Table 2. Statistics of the most popular services for bringing used cars from the USA and Europe in Ukraine (as of 09.2021) | 5 |
| Table 3. Calculation of payments of Mazda 3 2018 from the USA | 6 |
| Table 4. The average prices for the most common fuels (as of 09.2021) | 17 |
| Table 5. Summary statistics and description of variables (first model) | 31 |
| Table 6. Summary statistics and description of variables (second model) | 34 |
| Table 7. Summary statistics and description of variables (third model) | 35 |
| Table 8. Summary of the results of the first model | 36 |
| Table 9. Summary of the results of the second model | 37 |
| Table 10. Summary of the results of the third model | 38 |

# LIST OF ABBREVIATIONS

**EU** - European Union

**SUV** - Sport utility vehicle

# CHAPTER 1. INTRODUCTION

In the last years, the car market in Ukraine rivets the attention of the widest public. While the new car market stays quiet and predictable the secondary car market is seething. It received second wind with the import of secondary cars from Europe and the USA. Very quickly the car market became a theme in all kinds of debates starting form car enthusiasts and ending in the centre of Ukrainian political life. There are quite a few reasons why such occurred. At first, the economic one, low GDP growth and protectionism of local producers. Secondary, high price and low quantity of "normal" car, usually meaning cars that at least were not produced or design in USSR. Last but not least lack of transparency and trust, all the time or almost all times mileage is twisted, the accidents were hidden not to mention juridical fraud, even it not so common but still take place.

Visa-free with Europe and loopholes in law made it possible for Ukrainians to import second-hand cars and not to pay the customs fee. Subsequent changes to the law to solve the issue with the cars with European number plates made it possible to import damaged cars from the USA. Also, the COVID-19 pandemic. All of that brings even more mess to the car market.

The purpose of this study is a comprehensive overview of the market of used cars, trends, platforms and intermediaries for sale, as well as testing two hypotheses using hedonic pricing models.

The data for the model were parsed from the site auto.ria.com, so the methodology of this work, in addition to the specifics of models themselves, also includes web scraping technique in R programming language, as well as text mining elements with the help of which were created some variables.

Main results regarding hypotheses: cars that run on a Gas / Gasoline engine and which have overcome the mark of 100,000 km are cheaper than the same cars, only on a gasoline engine by about 26%. Diesel cars, which overcame the mark of 100,000 km, are more expensive than gasoline ones by 100,000 km. That is, the first hypothesis that the diesel type of engine can slow down the price drop from the fact that the car has traveled

more than 100,000 km has been confirmed. The second hypothesis result: the positive deviation from the rate of average annual mileage has positive impact on the price, but at the same time it is very scanty, which was not expected when the hypothesis put forward. So we can say that the second hypothesis was rejected at a half.

# CHAPTER 2. INDUSTRY OVERVIEW AND RELATED STUDIES

## 2.1. Analysis of online platforms for buying and selling used car

Buying and selling used cars is increasingly carried out through car sites, where you can buy not only cars from Ukraine, but also uncleared cars from the United States and Europe. The largest Internet platforms for buying and selling cars within Ukraine are:

- auto.ria.com
- RST.ua
- ab.ua
- cars.ua
- parkdrive.ua
- OLX/transport

Below are sites statistics collected with the help of www.similarweb.com, Google Trends and Instagram/Facebook pages. See Table 1.

Table 1. Statistics of the most popular auto platforms in Ukraine (as of 09.2021)

| Site | Total Visits, mln | Avg. Visit Duration, minutes | Pages per Visit | Bounce Rate, % | Google Trends | Instagram | Facebook |
|---|---|---|---|---|---|---|---|
| auto.ria.com | 18,17 | 11,38 | 13,51 | 25,32 | 26 776 | 71 000 | 199 251 |
| RST.ua | 7,41 | 10,44 | 23,37 | 22,37 | 23 988 | 780 | 1 627 |
| ab.ua | 0,25 | 2,45 | 3,35 | 48,82 | 20 450 | 2295 | 18017 |
| cars.ua | 0,18 | 3,08 | 3,77 | 53,39 | 2 942 | - | - |
| parkdrive.ua | 0,33 | 2,43 | 3,11 | 61,84 | 2 448 | 1 604 | 181 |
| automoto.ua | 0,98 | 7 | 9,35 | 34,92 | 7 467 | 11 100 | 500 972 |
| OLX/transport | - | - | - | - | 28 150 | - | - |

Explanation of the indicators of this table:

Total Visits - total number of visits for the entire history the site's existence (in million);

Average Visit Duration - average number of minutes spent on the site;

Pages per Visit - average number of pages on the site viewed by users;

Bounce Rate - the percentage of visitors which navigate away from the site after viewing only one page;

Google Trends - the level of popularity of a site based on the history of its searches on Google, in this case, over the past 12 months. In order for this indicator to be more accurate, it is necessary to collect statistics not for one site name, but for different ways of writing the name of this site. For instance, there is a site auto.ria.com: it is clear that not everyone enters the site name in Google verbatim, so considered different options: 'авториа', 'авторія', 'ауториа', 'ауторія', 'autoria', 'autoria.ua', 'auto.ria', 'auto.ria.com', 'авториа машины', 'авторіа машини', 'авториа бу', 'авторіа бу' and so on. The same logic was applied to other sites as well;

Instagram - number of subscribers in Instagram;

Facebook - number of subscribers in Facebook.

As you can see from Table 1, all but one of the values are absent in OLX/transport. The problem is that OLX / transport does not have its own website, it is part of a huge online classifieds platform that brings people together to buy, sell or exchange different goods (including cars) and services. But at the same time, the car market on OLX is very popular, as statistic of Google Trends says.

The undisputed leader in terms of 'Total Visits' is auto.ria.com - more than 18 million in its entire history. Also, this site has quite strong results for other indicators, including leadership in the number of subscribers on Instagram. The site automoto.ua does not have such good results, but at the same time it is the leader in the number of subscribers on Facebook, which is also very important in maintaining online business.

The website RST.ua has the best results in terms of 'Pages per Visit' and 'Bounce Rate'. That is, users are more likely to view more cars on this particular site than on some other,

and at the same time, they are more likely to continue to surf on this site after they hit its very first page.

This statistic is most useful for those who want to sell a car as soon as possible. The logic is to post ads on that site which has good indicators of parameters described above. Now about the pricing policy of platforms that car sellers can use. Consider the example of RST.ua: one ad can be placed for free. Two or more ads can be published for free if they were previously paid (there was a first payment). Ads older than 3 months are automatically deleted. If the seller wants the photo of the car in search to be larger than others, he must pay for this service. How much does it cost? 0.1%/month - from the price of the car. The price of the car is calculated from the average market price of a similar brand/model/year of manufacture. For example, if the price of a car is UAH 200 000. - the cost of advertising 200 UAH/month.

Also, Ukrainians use platforms that specialize only in selling used cars from the USA or from Europe. The most popular of them and statistics on them in Table 2 below.

Table 2. Statistics of the most popular services for bringing used cars from the USA and Europe in Ukraine (as of 09.2021)

| Platform | Total Visits, mln | Avg. Visit Duration, minutes | Pages per Visit | Bounce Rate, % | Google Trends | Instagram | Facebook |
|---|---|---|---|---|---|---|---|
| *Atlanticexpress* | 0,26 | 3,36 | 4,5 | 49,47 | 1 678 | 12 600 | - |
| *Americanavto* | 0,08 | 3,13 | 2,65 | 58 | 1 537 | 17 600 | 6 271 |
| *Columbauto* | 0,44 | 3,14 | 4,23 | 54,47 | 2 040 | - | - |
| *Autoscout24* | 0,07 | 9,33 | 11,71 | 20,36 | 3 535 | - | - |
| *plc.ua* | 0,47 | 2,02 | 9,44 | 51,31 | 2 992 | 29 200 | 27 324 |
| *Autodealerr* | - | - | - | - | - | 266 000 | - |

Autoscout24 should be noted right away: this platform is the best in terms of 'Average Visit Duration', 'Pages per Visit', 'Bounce Rate' and 'Google Trends'. This platform is a European product, but at the same time their website with the '.ua' domain in Ukrainian or Russian languages is accessible for Ukrainians. But at the same time, there are no Ukrainian versions of Instagram and Facebook pages.

Interesting case with Autodealerr. The undisputed leader among followers on Instagram, it has their own website, but at the same time there is so little traffic data that it was impossible to calculate the parameters we were interested in. Therefore, most of their clients from only one source – from Instagram.

In general, how to buy a car from abroad, for example from the United States. You apply to a company that selects a car for you at auctions. What is included in the price of the car from the US: lot price + auction fee, delivery of the car by land and sea, additional commission for sending funds to the auction, unloading from the port, delivery from the port (usually cars from the US arrive at the port of Odessa and delivery , for example in Kiev, paid separately), brokerage services, customs clearance, dealer services. Consider the real case for greater accuracy. For example, you bought a 2018 Mazda 3 from the United States. All calculations are given in the table below:

Table 3. Calculation of payments on the example of Mazda 3 2018 from the USA

| | | |
|---|---|---|
| Lot cost + Auction fee | 3965$ | |
| Delivery by land + sea | 1300$ | |
| Additional commission for sending funds to the auction | 69$ | |
| Unloading from the port | 1150 $ | 250 $ |
| Delivery from the port in Kyiv | | 650 $ |
| Brokerage services | | 250 $ |
| Customs clearance | 1813$ | |
| Dealer services | 600$ | |
| **Final cost** | **8897$** | |

That is, in this case, the company that provide services for the purchase of cars from the United States charge $ 600 for their work. All other costs relate only to the car and its transportation.

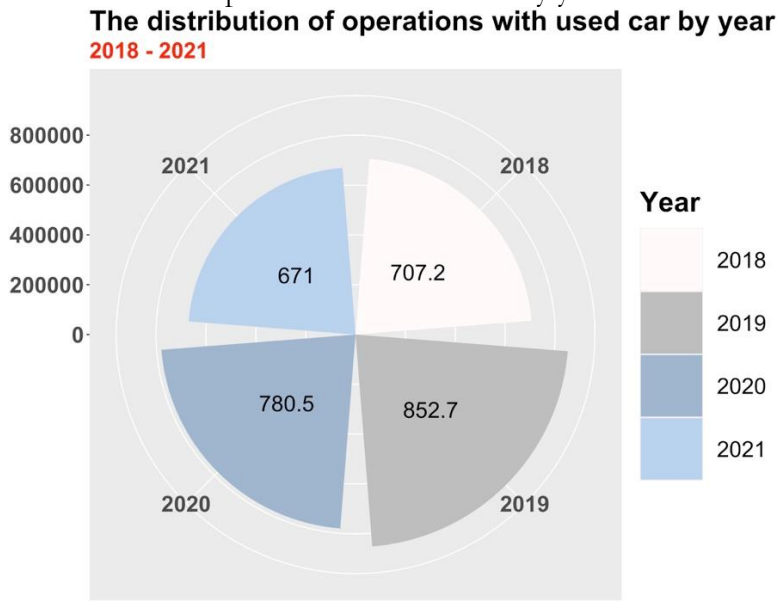
In this subheading, two clusters for the purchase and sale of used cars were considered: the first cluster - the most popular global sites in Ukraine, the second cluster - those sites that specialize only in bringing cars from the USA and Europe. Statistics on these two clusters are useful for analysis not only for those who want to buy or sell a car,

but also for these platforms themselves, which will be able to make comparisons in traffic with their competitors.

### 2.2. Main trends in the used car market of Ukraine for 2018-2021

According to paragraph 2 of the Procedure for State Registration of Vehicles, approved by the Cabinet of Ministers of Ukraine dated September 7, 1998 № 1388, all vehicles of individuals and legal entities must comply with the procedure for registration by territorial bodies for the provision of services of the Ministry of Internal Affairs. All operations performed with vehicles are entered into the database (data.gov.ua), where there is basic information on each car: brand, model, year, color, engine capacity, body type, fuel type, registration number, type of operation performed with this car and so on. There is also information about the owner of the car: either an individual or a legal entity. To analyze the main trends in the used car market of Ukraine the data for 2018-2021 was scraped from data.gov.ua. This research only interested in those cars that belong to individuals, as well as only light cars. Therefore, first of all, we filter out unnecessary information. Also, this study concerns only the purchase and sale of used cars either from Ukraine or from abroad, therefore we delete all data that does not relate to these operations. As a result, the final dataset after many manipulations began to amount to 3 million 11 thousand 395 operations with used cars for 2018, 2019, 2020 and 8 months of 2021. The Figure 1 below shows the distribution of the number of transactions by year.

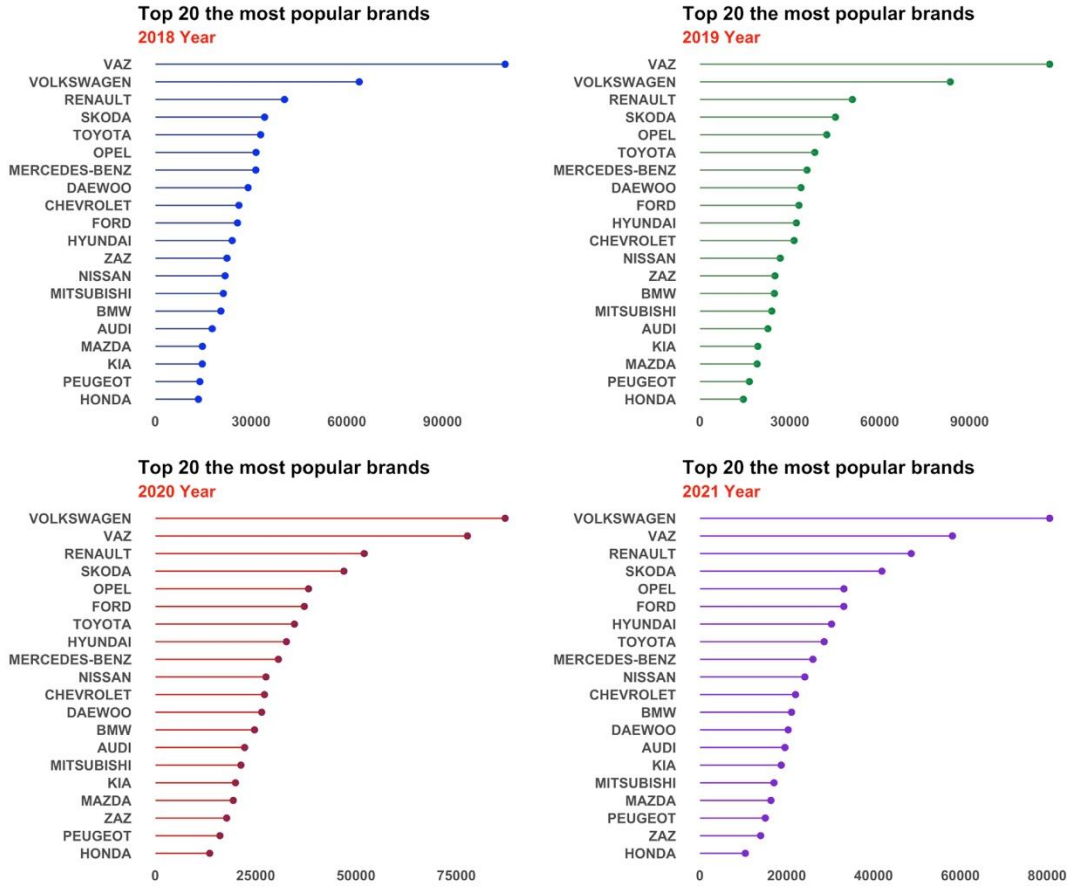
Figure 1. The distribution of operations with used car by year




The graph shows that the total number of transactions with used cars is the highest in 2019 - about 853 thousand which is 17 % points more than in 2018. In 2020, it decreased by 8.5 %. There is nothing strange about this, because since March 16, 2020, the authorities have introduced the most severe quarantine measures that block not only the implementation of many services, some goods, but also the functioning of the departments themselves for the registration of vehicles. This influenced the fact that the total number of transactions (not only with used cars) in 2019 exceed the number of transactions in 2020 by approximately 28%. On the account of 2021: it is too early to draw conclusions, since the data for the entire calendar year will be available only in January 2022.

The following Figure 2. shows the top 20 the most popular brands among used cars each year. In 2018, VAZ was leading by a wide margin, ahead of its closest competitor VOLKSWAGEN by almost 42 %. In 2019, VAZ was also in the lead, but not by such a significant margin compared to VOLKSWAGEN: almost 29 %. In 2020 and 2021, VAZ and VOLKSWAGEN switched places.

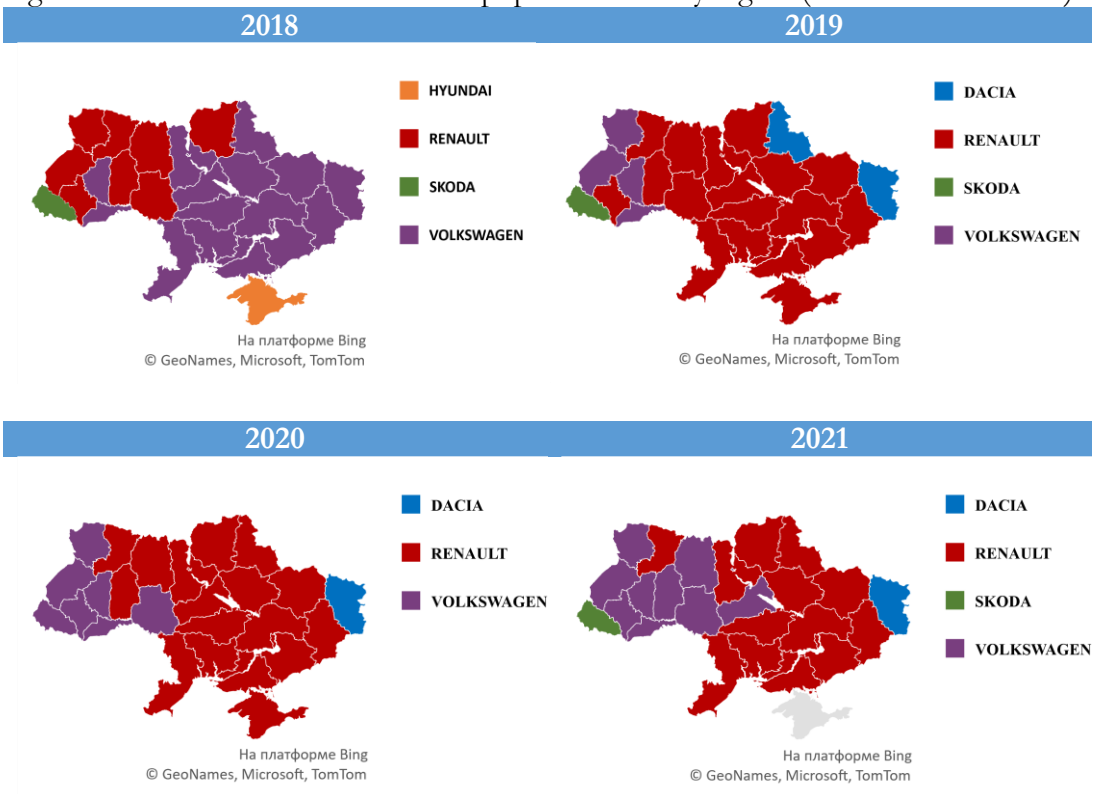
Figure 2. Top 20 the most popular brands 2018-2021




Looking at the graph, we can also see a downward trend in the popularity of the ZAZ brand every year: its place is lower and lower.

If we consider the most popular brands in the context of regions and origin (the transaction was made with a car that was brought from abroad in this case), then it will look like this: see Figure 3.

Figure 3. The distribution of the most popular brands by region (Abroad 2018 – 2021)




As can be seen from Figure 3 in 2018 in 15 regions of Ukraine, as well as in the city of Kiev, the Volkswagen brand had an advantage. This brand accounted for almost 16,5% of abroad operations among all brands. In the second place in terms of the number of abroad operations is the RENAULT brand (approximately 14,1%), and at the same time it was the leader in 9 Oblasts.

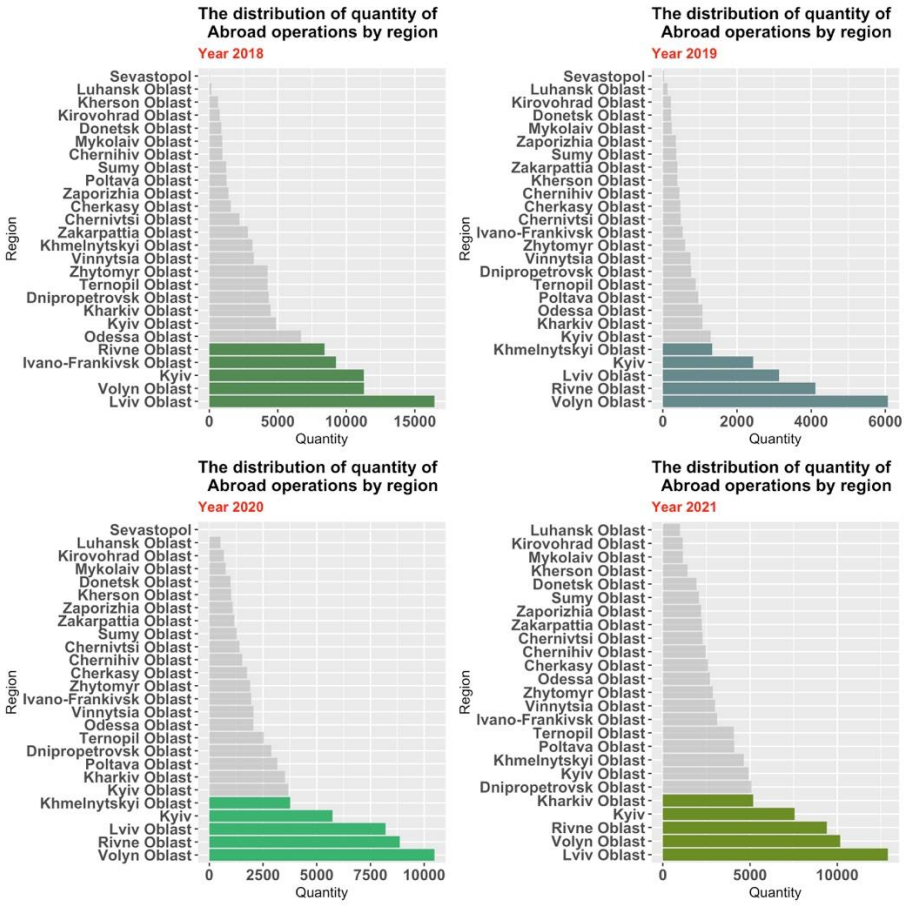
In 2019, the situation is changing dramatically: Dacia (almost 5,8% of abroad operations in 2019) begins to lead Sumy and Luhansk Oblasts, Volkswagen (14,4%) – in Volyn, Lviv, Ternopil and Chernivtsi Oblasts as well as Renault (18,7%) – in all other 17 oblasts and the city of Kyiv. Skoda's (8,8%) leadership in Zakarpattia region remained unchanged. In 2020, Volkswagen (17,1% of abroad operations in 2020) , in addition to those areas, which it led in 2019, also takes control of Zakarpattia, Ivano-Frankivsk and Vinnytsia Oblast. Dacia (5,2%) is starting to become the most popular only in the Luhansk Oblast, in all other regions in 1st place – Renault (18,2%). In 2021 Skoda (11,8% of abroad

operations in 2021) is again the leader in the Zakarpattia Oblast. Volkswagen (19,5%) has expanded its popularity map to Khmelnytskyi, Zhytomyr and Cherkasy Oblasts. Dacia (4,5%) again only in the Luhansk Oblast and in all other regions – Renault (17,9%). Thus, at the moment, the most popular car that is brought from abroad is Volkswagen.

If we talk about the number of transactions with used cars from abroad by region, it looks like this: see Figure 4 below (the top 5 regions with the largest number are highlighted in color). Over the past 4 years, the leaders in the number of transactions with cars from abroad were either the Volyn region or the Lviv region. And in general, such representatives of the West as: Khmelnytskyi, Rivne and Ivano-Frankivsk Oblasts have quite strong positions. This is not surprising, since they are located close to the border with the EU countries.

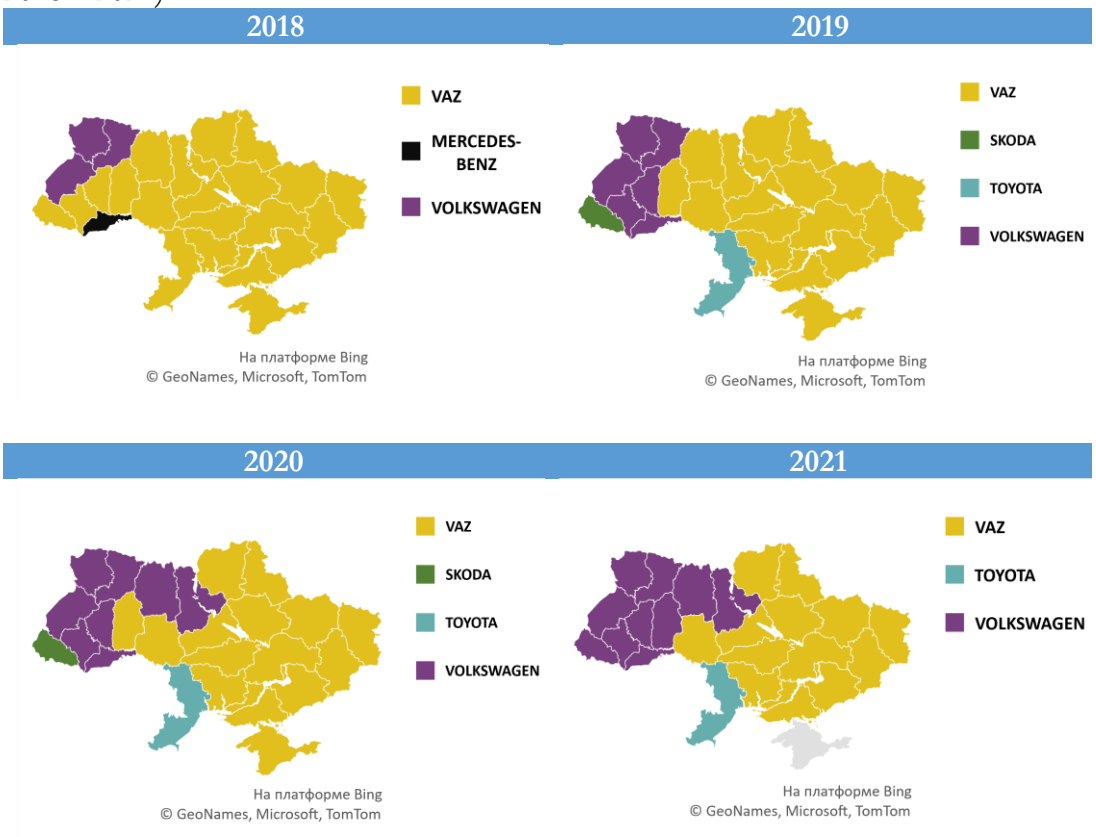
About the total number of transactions with used cars from abroad: in comparison with 2018, in 2019 the indicator has decreased by approximately 73%. But already in 2020 in comparison with 2019 it grew by 60%, and in 8 months of 2021 the total quantity grew by 71% (also in comparison with 2019). In 2018 the percentage of transactions with used cars from abroad of all transactions was approximately 13%, in 2019 - 3,4%, in 2020 - 9,3% and in 2021 - almost 15%. That is, over the past two years, Ukrainians have been dealing more and more with cars from abroad.

Figure 4. The distribution of quantity of Abroad operations by region (2018 – 2021)




Regarding those cars, operations with which are not identified as with cars from abroad, the absolute leader in popularity is the VAZ brand: in 2018, it was number one in 20 regions of Ukraine, in 2019 - in 16, in 2020 - in 14 and in 2021 - in 13. The second is the same Volkswagen. As a rule, it is most popular in Western Ukraine and in Kyiv city, while VAZ is most popular in the East, South, North-East and Central Ukraine. In 2019, 2020 and 2021, the place of VAZ in the Odessa region was taken by the Toyota brand, and in 2019 and 2020 in Zakarpattia Oblast Skoda was in first place. In 2018 Mercedez-benz was the leader brand in Chernivtsi Oblast. See Figure 5 below.

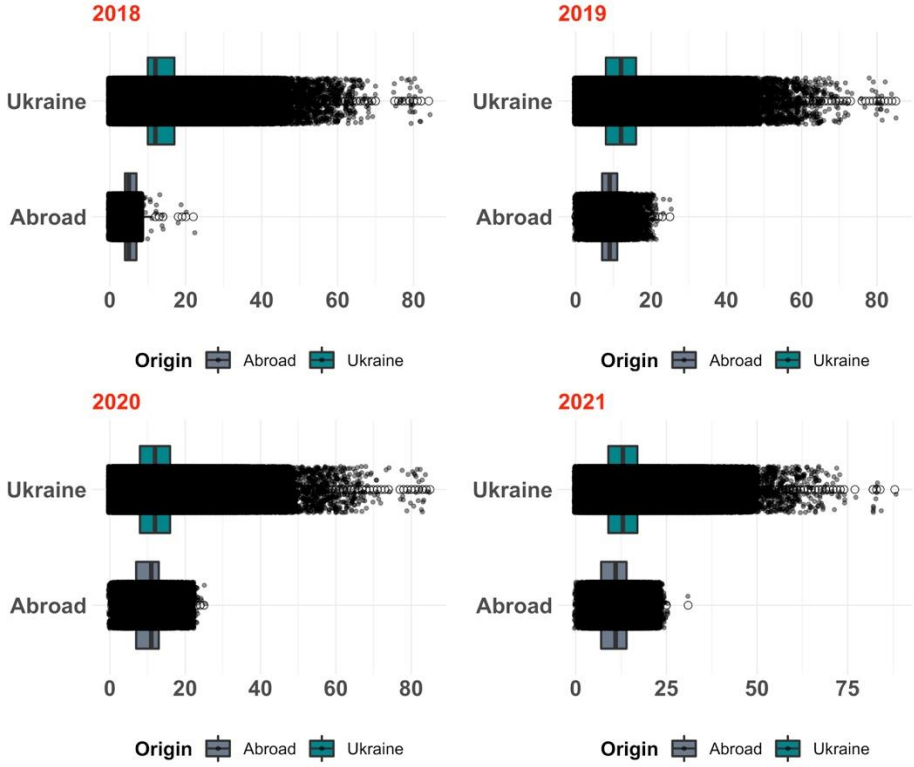
Figure 5. The distribution of the most popular brands by region (Ukrainian transactions 2018 – 2021)




Although VAZ is considered the most popular car in many regions of Ukraine, the percentage of transactions with this brand of the total number is becoming less and less. In 2018, the indicator was 18.3% (from those cars which are not identified as cars from abroad), in 2019 - 14.2%, in 2020 – 10,9% and in 2021 - 10.2%. By the way, in 2021, the percentage of transactions with Volkswagen is higher and amounts approximately 10.7%.

Figure 6 below shows the distribution of the age of cars depending on what kind of transaction took place with them: as with a car from abroad, or as with a Ukrainian one. It immediately becomes noticeable that operations with the oldest cars were carried out exactly with those cars that were registered on the territory of Ukraine earlier.

Figure 6. Cars' age by Origin 2018-2021




The average age of cars that were previously registered in Ukraine was approximately 14 years old in 2018-2021. If we talk about cars from abroad, then in 2018 the average age was almost 5 year (that year most of the cars were almost new), in 2019, 2020 and 2021 - about 9-10 years for each. By the way, the oldest cars (not from abroad) turned out to be far from the cars of the Soviet car industry: Mercedes benz (290) 1934 year of issue, Dodge (VS) 1934 year of issue, Opel (20103) 1935 year of issue, Opel (Super) 1933 year of issue in 2021, 2020, 2019 and 2018, respectively. The oldest models from abroad were Hyundai (Matrix) 2001 year of issue, Mercedes-Benz (E220) 1994 year of issue, Porsche (911 Turbo) 1995 year of issue and Mercedes-Benz (190) 1990 year of issue in 2018, 2019, 2020 and 2021 respectively.

Figure 7. Cars' age by body 2018-2021

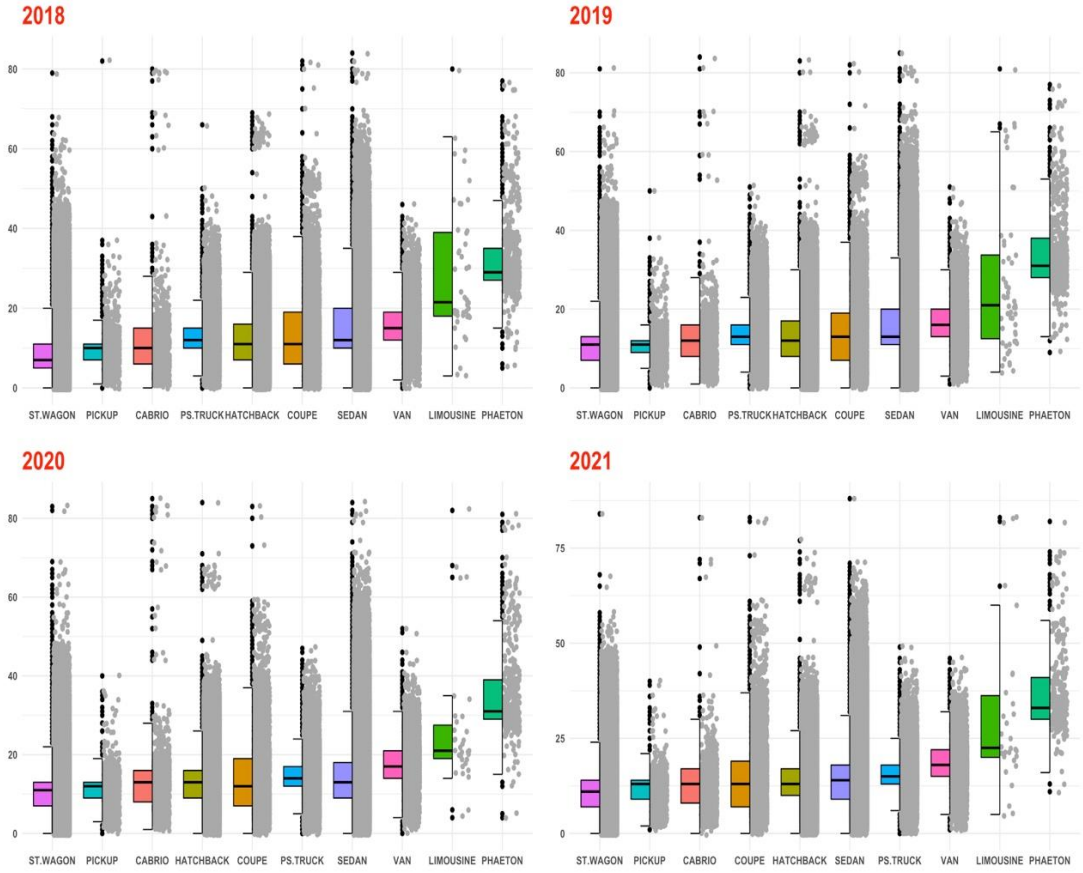



Figure 7 below shows the distribution of the age of a car depending on its body type. On average, in 2018-2021, the oldest cars are phaetons. For example, their average age in 2021 is approximately 37 years. On the contrary, the station wagons are the newest cars in 2018-2021. Their average age in 2021 is 11 years. By the way, the station wagon is the most popular body type among those cars that are imported from abroad. In 2018, almost 60% of all overseas transactions were with station wagon, in 2019 - 70%, in 2020 - 72% and in 2021 - 74%. If we consider the market inside Ukraine, then the most popular type of body is the sedan. In 2018, 45% of operations with this type of body were performed, in 2019 - 40%, in 2020 - 38% and in 2021 - also 38%.

Figure 8. Top 20 the most popular models 2018-2021

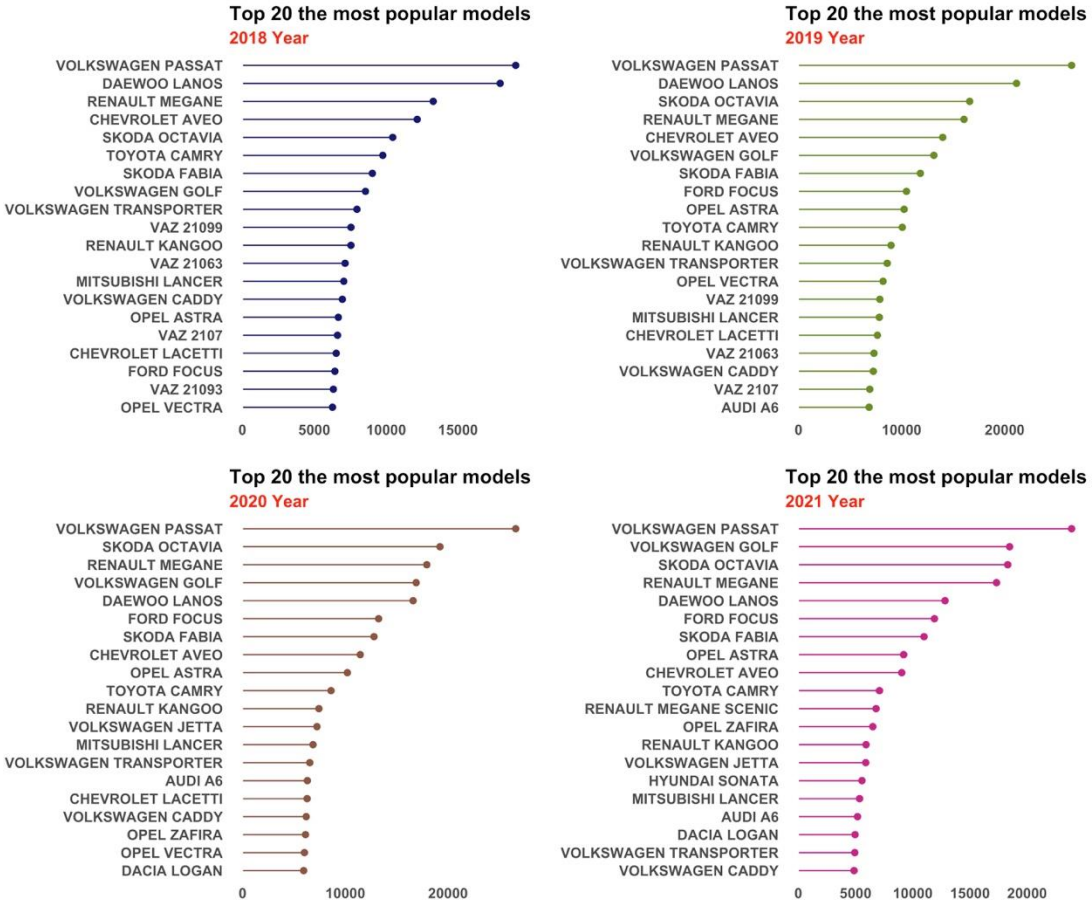



Figure 8 represents the top 20 most popular models 2018-2021. Volkswagen Passat has been the leader in Ukraine for the last 4 years. In 2018, the percentage of all transactions (abroad and not abroad) with this model was approximately 2.7%, in 2019 - 3.1%, in 2020 - 3.4% and in 2021 - approximately 3.6%. Without exaggeration, the Passat, for now, is number 1 in terms of demand. Also among the leaders are such brands as: Skoda Octavia, Renault Megane, Daewoo Lanos. They have been in the top 5 for the last 4 years.

When viewed in the context of the origin of the car, the most popular model from abroad in 2018-2021 was the Renault Megane. The top 5 also includes such models as: Volkswagen Passat, Skoda Octavia, Volkswagen Golf, Ford Focus, Renault Kangoo (in 2019). In the context of operations with Ukrainian cars, the most widespread model in 2018 was Daewoo Lanos. Then, in 2019-2021, the leader is Volkswagen Passat. Also in the top 5 in different years were Chevrolet Aveo (2018 and 2019), Toyota Camry (in 2018),

Volkswagen Transporter (in 2018), Skoda Octavia (2019-2021), Renault Megane (2019-2021) and Volkswagen Golf (2020-2021).

It is also important to understand the type of fuel that is most common on the secondary car market in Ukraine. There are two main types of fuel for cars: gasoline and diesel, and alternative types: gas, electricity, hydrogen. There are also many more exotic fuels that are hardly ever used in production cars. In 2018-2021, the most popular type of fuel is gasoline. In 2018, this type of fuel accounted for 43% of operations, in 2019 - 40%, in 2020 – 45,5% and in 8 months of 2021 - almost 46%. Also, a large segment is made up of such groups: diesel or gasoline + gas (a special gas cylinder is additionally installed in the car). In 2018, they were 26% and 29%, respectively, in 2019 - 28% and 31%, in 2020 - 28% and 24%, and in 2021 - 29% and 23%. The prices for the most common fuels are in Table 3 below.

Table 4. The average prices for the most common fuels (as of September 2021)

| **Type of fuel** | **Price (in hryvnia) per liter** |
|---|---|
| *Gasoline A-95 premium* | 31.97 |
| *Gasoline A-95* | 30.10 |
| *Gasoline A-92* | 29.22 |
| *Diesel fuel* | 28.51 |
| *Car gas* | 17.71 |

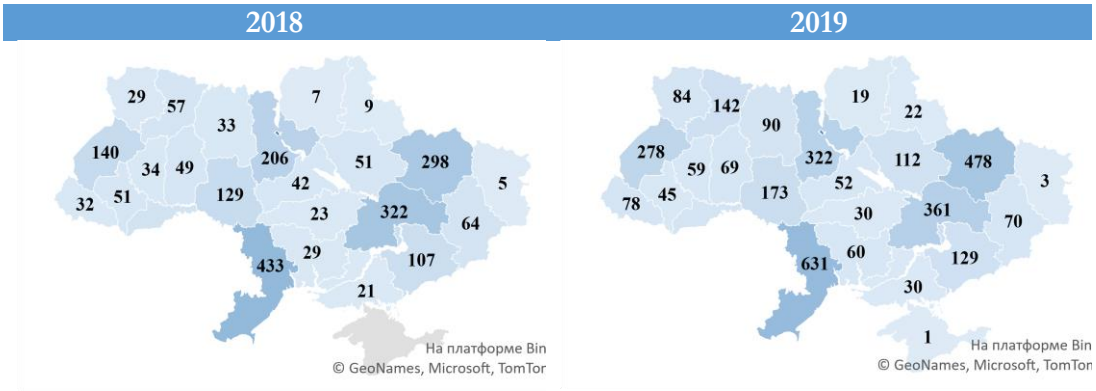
*Source: minfin.com.ua*

The fuel tank capacity of passenger cars ranges from 45 liters for small cars and to 100 liters for large SUVs. On average, the standard declared volume is 50-55 liters. The actual capacity, as a rule, is 10-15% more, that is, on average, in order to completely fill a 50-liter tank with ordinary gasoline A-95 now costs about 1,500 hryvnia, diesel - about 1,425 hryvnia. If we talk about gas, then despite the higher consumption per 100 km, it is more economical and on average it will cost about 500-600 hryvnia for 45 liters (due to the physical characteristics of the gas, a cylinder of such capacity is not filled to the end, leaving space).

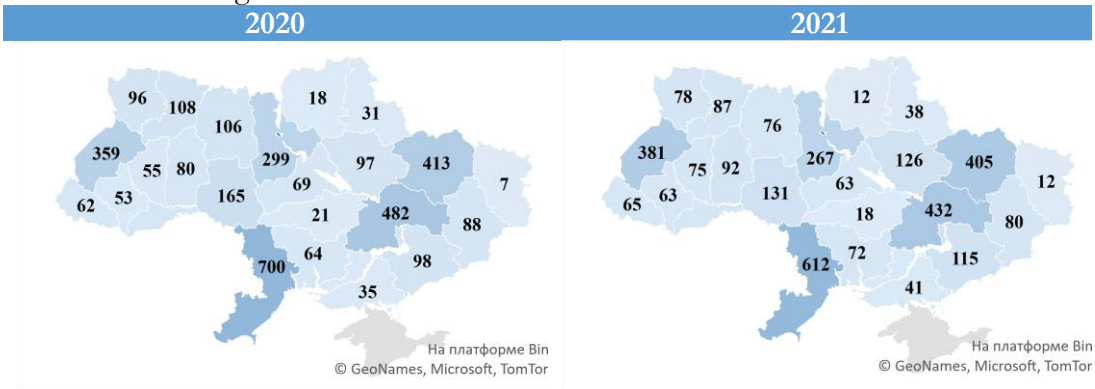
At the moment, the most economical type of vehicles in terms of the resource of movement are electric vehicles. Alas, Ukrainians are very slowly moving towards a massive

transition to these more environmentally friendly cars. The share of used electric vehicle operations in 2018–2021 ranged from 0.46% in 2018 to 0.72% in 2021. The most popular vehicle in this category is the Nissan Leaf. In 2018, the share of the Nissan Leaf among electric cars was 69%, in 2019 - 54%, in 2020 - 40% and in 2021 - 37%. On a full charge, an electric car can travel up to 230 km. The car charges from a home outlet 8 hours. The battery of this car has the following characteristics: 24 kWh. Today, according to the Cabinet of Ministers of Ukraine, the single tariff for household consumers is 1.68 UAH/kWh. That is, a full charge of the car will cost about 41 hryvnia. The power consumption of Nissan Leaf for every 100 km of the car is 18 hryvnia - a ridiculous amount compared to other types of fuel. And the first reason why Ukrainians are not so active in promoting electric cars is the price. On the official website www.nissan.ua, the new Nissan Leaf costs from 35,000$ dollars, and if you revise the prices for used cars of this model, then on average such a car costs up to 15,000$ with a mileage of up to 20,000 km. The second reason is, alas, the "refueling" of such cars in Ukraine is still a certain difficulty in the form of a lack of electric refueling stations in peripheries. But this is a matter of time, environmental standards are constantly being tightened, fuel prices are growing, and alternative energy sources are being actively introduced. Therefore, every year there are more and more power plants in Ukraine. Figure 9. below illustrates the distribution of the number of operations with electric cars by region.

Figure 9. The distribution of the number of operations with electric cars by region 2018-2021

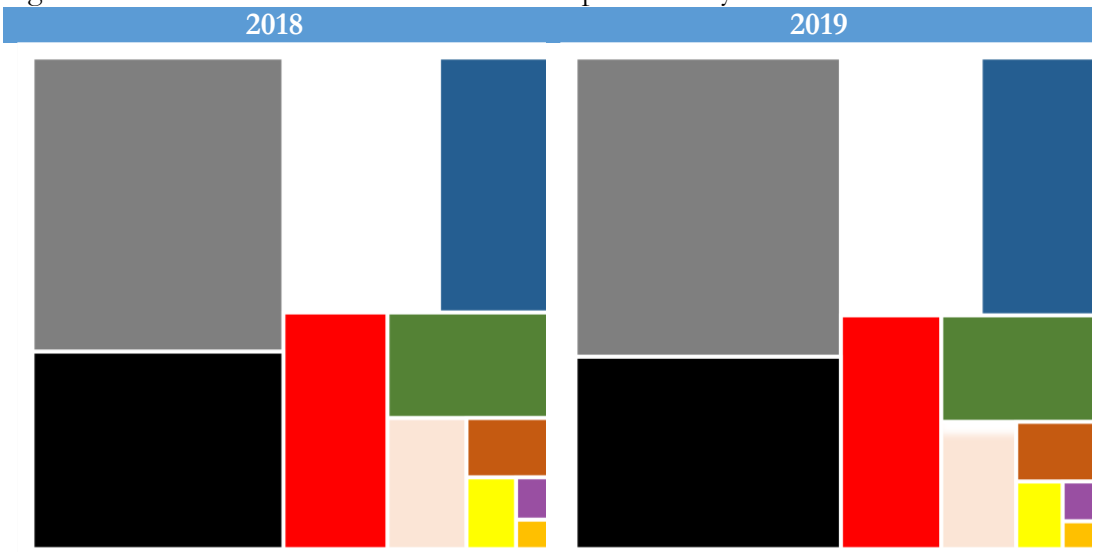


Continuation of Figure 9.




As expected, the largest number of transactions with electric cars is in Kiev city (not visible on the map) - approximately 31% of the total in 2018-2021. In 2018-2021, the TOP-5 (except Kiev city) included Odessa Oblast (average share for 4 years 13%), Dnipropetrovsk Oblast (9%), Kharkiv Oblast (8%), Kyiv Oblast (almost 6%) and Lviv Oblast (6%). The last on the list in 2018-2021 is the Luhansk and Chernihiv regions.

Figure 10. The distribution of the number of operations by colors 2018-2021



Continuation of Figure 10.

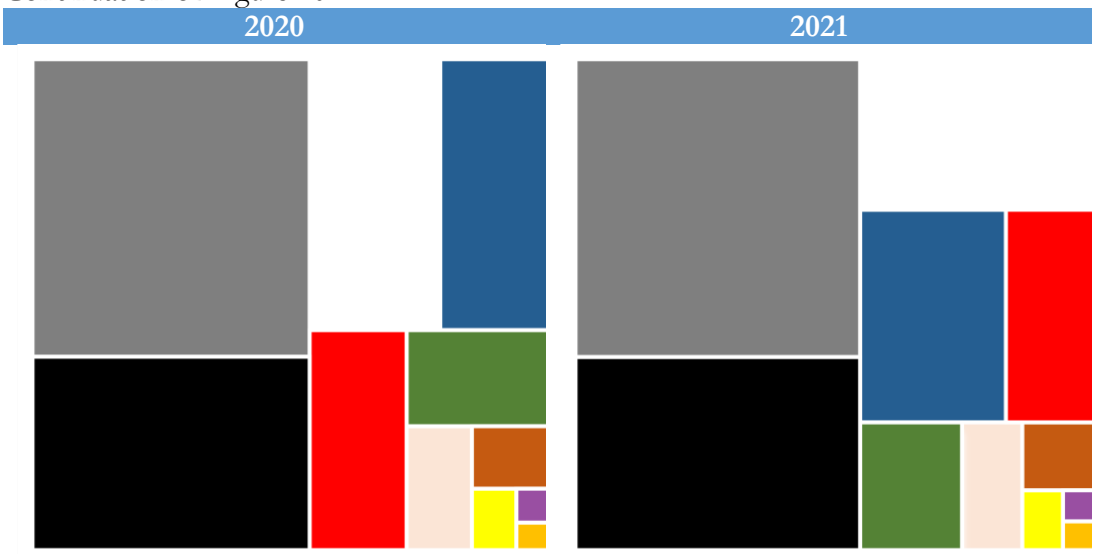



Figure 10 illustrates which used car colors are the most popular among Ukrainians. The undisputed leader in 2018-2021 is gray. The share of operations with machines of this color is 29%, 31%, 32%, 33% in 2018,2019,2020 in 2021, respectively. The top 5 in 2018-2021 also includes cars of black (on average 20% share), white (14%), blue (11%) and red (8%) colors.

### 2.3. Related studies

In 2010, a scientific work was published by Qin Fan, who under the mentorship of Jonathan Rubin did research on topic "Two-Stage Hedonic Price Model for Light-Duty Vehicles: Consumers' Valuations of Automotive Fuel Economy". The main goal of this study is to assess the marginal willingness of consumers to pay for a change using hedonic regression of new car sales. At the same time, there are models that was built by the author and looked as follows:

$$log(MSRP) = \beta_1 + \beta_2\, class + \beta_3\, log(MPG) + \beta_4\, log(weight) + \beta_5\, log(HP.WT) + \beta_6\, transmission + \beta_7\, manufacturer + \beta_8\,(class \times log(MPG)) + \beta_9\, luxury + \beta_{10}\,(luxury \times log(MPG)) + \beta_{11}\,(class \times log(weight)) + \beta_{12}\,(class \times log(HP.WT)) + \beta_{13}\,(luxury \times log(HP.WT)) + \beta_{13}\,(luxury \times log(weight)) + \varepsilon_t \quad (2.1)$$

$$log(MSRP) = \alpha_1 + \alpha_2\, log(MPG) + \alpha_3\, log(weight) + \alpha_4\, log(HP.WT) + \alpha_5\, transmission + \alpha_6\, manufacturer + \alpha_7\, type + \alpha_8\,(type \times log(MPG)) + \alpha_9\,(type \times log(weight)) + \alpha_{10}\,(type \times log(HP.WT)) + \varepsilon_t \quad (2.2),$$

where:

MSRP ($) – Manufacturers' suggested retail price;

Class – small, midsize or large cars (first equation);

Luxury – 0 if car does not represent luxury segment, 1 if it does (first equation);

HP.WT(hp/lbs) – Power–weight ratio (The higher indicator, the faster the vehicle will accelerate);

MPG – Combined fuel economy (mpg) 1/(0.55/mpg city + 0.45/mpg hway). The higher a car's MPG, the more fuel efficient it is.

Weight – Vehicle curb weight (lbs);

Manufacturer – Automobile manufacturers containing 17 companies;

Transmission – auto = 1, manual = 0;

Type – Sport utility vehicle, pickup or van (second equation);

The first equation was built for ordinary light cars, the second for trucks. The data that the author took as a basis for this model was taken only within the state of Maine (Source: Ward's Automotive Group, and vehicle registrations records were bought from the Maine Information Resource) and constitutes information on 523 and 2100 transactions with new light cars and trucks respectively.

Some results: small car (base category) buyers are willing to pay $208 and van (base category) buyers are willing to pay $1,822 for an increase in fuel economy of 1 mpg. The author calculated this as follows: he took the average value of MSRP and MPG for light

cars and trucks, divided the first by the second and multiplied by the coefficient that formed near the MPG in the corresponding equation. The formula is below:

$$\frac{Mean(MSRP_{\beta/\alpha})}{Mean(MPG_{\beta/\alpha})} \times \beta/\alpha_{mpg} \quad (2.3)$$

The author also calculated a similar indicator in the context of other categories. For example, for truck buyers: SUV owners or operators are willing to pay $379 for a marginal increase of fuel economy, whereas pickup buyers are willing to pay only $154 for a marginal decrease of fuel economy. Mathematically, it looks like this:

$$\frac{Mean(MSRP_{\alpha})}{Mean(MPG_{\alpha})} \times (\alpha_{mpg} + \alpha(type \times log(MPG)) \quad (2.4)$$

In 2020, KSE student Tetiana Proshchyna, under the guidance of Professor Elena Besedina, wrote a scientific work on the topic "Estimation of hedonic pricing model for light vehicles: the case of Ukrainian market for new cars". In her hedonic regression, she used the following variables:

Brand – automobile manufacturers containing 20 companies (dummies);

Year – year of produce (dummies);

Transmission – automatic, mechanic, robotic, tiptronic or variator (dummies);

Wheel drive type – front, back or full (dummies);

Engine type – gasoline, diesel, diesel/electric, electric, gasoline/electric or gasoline/gas (dummies);

Leather interior – leather or not (dummy);

Horsepower – continuous variable in hp ;

Body type – crossover, cabriolet, city-car, coupe, fastback, hatchback, liftback, pickup, roadster, sedan, station wagon or SUV (dummies);

Region – Kyiv, West, East, South or Center (dummies);

Availability – if car is not available and should be ordered (dummies);

Curb weight – car weight (kg)

The data used in the model contains 6219 observations about new cars. The information was scraped from auto.ria.com - a platform for buying and selling cars. The author's model was bult in method of semi-logarithmic specification.

Some results: the greatest price fluctuations are caused by brands. Ceteris paribus, the cars with mechanic transmission are 12% cheaper that those with automatic. If we talk about tiptronic, then this type is 22% more expensive in comparison with the automatic transmission, ceteris paribus. Full-wheel drive cars are priced 5% higher than front-wheel drive, and back-wheel drive is 4% lower, ceteris paribus. Cars with a diesel engine is 15% more expensive in comparison with cars with a gasoline one. An electric car is 11% more than a gasoline car. If the car is a hybrid (diesel / electric or gasoline / electric), then the price is 27% and 12%, respectively, higher than a car on gasoline. About the car body type, roadster is the most expensive car body type.

In 2014, a scientific article was published by Marc Prieto, Barbara Caemmerer and George Baltas "Using a hedonic price model to test prospect theory assertions: The asymmetrical and nonlinear effect of reliability on used car prices", where the hedonistic model was also built.

The data used to build the model is consists of 1,735 observations about used cars from the popular French website Leboncoin.fr from January to March 2012. In the model, the authors used the following attributes as variables:

Asking price (dependant variable) – in Euros;

Age – Vehicle age in years;

Mileage – in km;

Engine power – horsepower;

Engine type – 1 if diesel, 0 otherwise;

Car segment – small, monospace, compact or midsize;

Extras – metallic paint, ABS, cruise control, air condition and navigation (dummies);

Seller Type – 1 if seller is a professional retailer, 0 otherwise;

Seller location – Capital, Northeast, Northwest, Southeast or Southwest

It is important to note that variables such as Asking price and Age have been logarithmized. Also, special variables such as Curve and Slope were created. In short about them: a very important indicator of the quality of a used car is its average annual mileage. For cars that run on gasoline, the best option would be 15,000 km, and for diesel ones - 25,000 km. A car with an annual mileage below those indicators is considered as a higher quality car. The difference between the actual annual mileage and the recommended mileage above is presented in the form of a cube root as variable Curve. The variable Slope – dummy, 0 if annual mileage is lower than the recommended, 1 if it is higher. Also, in addition to Engine type, the Engine type II variable was used, which means: 1 if engine type is diesel and total car mileage is up to 100,000 km, 0 otherwise.

The hedonic pricing model was built with IV correction. The authors had an assumptions that variable Seller Type was endogenous. Thus, the round kilometers (roundkms) and the duration of the time the advertisement was posted (timepost) are used as instrumental variables for the seller type variable.

Some results: an additional year decreases the car price by 25,7% for a one year old car (ceteris paribus). A diesel engine increases the price by 17,5%. Air conditioning has the strongest positive impact out of the five optional attributes. The type of engine is a retarder in the decline in the value of used cars in the sense that diesel cars with higher mileage have a better residual value. Deviations from the recommended annual mileage have a positive impact on prices.

# CHAPTER 3. METHODOLOGY

Taking into account the above studies, it was decided to build a hedonic pricing model, but, of course with some changes, which are very essential for the quality of the model.

First of all, consider the hypotheses around which the study will be based:

- Hypothesis №1 - the diesel type of engine mitigates the price drop if the car has traveled more than 100,000 kilometers. What this means is that if a car has a diesel engine and has driven more than 100,000 kilometers, it will be more expensive than a car that has a petrol engine and has also traveled more than 100,000 kilometers.
- Hypothesis №2 - a positive deviation from the average annual mileage (depending on the type of engine) has a significant positive impact on the price of the used car.

More about the variables described by these hypotheses and how they were formed in Chapter 4.

The market for used cars is very specific from a technical point of view, so the modeling in this case has many pitfalls in the form of multicollinearity. Therefore, it makes it impossible to simultaneously use all the characteristics of the car in one model. For example, if we take the variable Transmission and the variable Drive. Technically, the Robot and Mechanics gearboxes correlate very strongly with the front-wheel drive. Simultaneous use of these variables can distort the coefficients, which makes their further interpretation meaningless. A similar situation with brands and body type: Land Rover correlates very strongly with the Crossover body type. As for the type of fuel, for example, cars with a gas engine have a very strong connection with the body type of the sedan, limousine body type, as a rule, drives mainly on gasoline engines, electro cars – mainly hatchbacks. That is, the conclusion is as follows: it is necessary to study in detail the relationships between variables either with the help of a correlation matrix or with the help of descriptive statistics.

As a conclusion, for the study it was decided to use only those cars that run on diesel and gasoline engines (for the first regression). Brands such as Ssang Yong, Porsche, VAZ, GAZ, ZAZ, Chery, Daewoo, Geely, Lexus, Infiniti, Jeep, Dodge, Suzuki, Honda and Chevrolet were

removed to increase the representativeness of the sample. Mostly these brands run on gasoline engines.

So, three models were built. The first model looks like this:

$$log(Price) = \beta_1 + \beta_2\, log(Age) + \beta_3\, Body + \beta_4\, Technical + \beta_5\, Fuel + \varepsilon_t \quad (3.1)$$

The second model has the next look:

$$log(Price) = \beta_1 + \beta_2\, Curve + \beta_3\, Transmission + \beta_4\, Garage\_storage + \varepsilon_t \quad (3.2)$$

The third model has the next look:

$$log(Price) = \beta_1 + \beta_2\, Individual\_equipment + \beta_3\, (Dummy\_mileage \times Fuel) + \beta_4\, Service\_book + \varepsilon_t \quad (3.3)$$

The first model is for a general overview of the influence of variables. The second model was built, again, for reasons of multicollinearity: the variable log(Age) is highly correlated with the variable Curve (a variable that is key to Hypothesis №2). The same can be said about the intersection of the variables Dummy_mileage (indicates whether the car has traveled more than 100 thousand kilometers or not) and Fuel. The situation with the variables Individual_equipment and Service_book is as follows: they correlate with the technical condition of the machine. As a rule, those cars that are not on the move do not have a service book or are not individually equipped. The third model was built because the variable Curve correlates with the intersection of the variables Dummy_mileage and Fuel. The specificity of variable Curve is that it was calculated artificially based on the age of the car and the mileage. That is, in one model these variables cannot be. Since the purpose of this study is not to predict the market price of used cars, but to show the relationship, such a solution is appropriate.

It is important to note that almost all of the variables in models are dummy. Variables of this type take the values 0 or 1. For example, Body is 1 for Sedan and 0 for other car bodies, and so on. There are many examples of dummy variables, but in essence, a dummy variable is just a variable that takes only 2 values: either 0 or 1, other values are excluded (Basic Econometrics Damodar N. Gujarati, Chapter 9).

Variables Price, Age and Curve are not dummy variables. In the equation above, Price and Age are presented in logarithmic form because taking the logarithm converts asymmetric data to more symmetric. This can be identified using the distribution histogram. About the Curve variable, its values are the result of the action of the cube root. The idea of taking this variable came from "Using a hedonic price model to test prospect theory assertions: The asymmetrical and nonlinear effect of reliability on used car prices" (2014) Marc Prieto, Barbara Caemmerer and George Baltas.

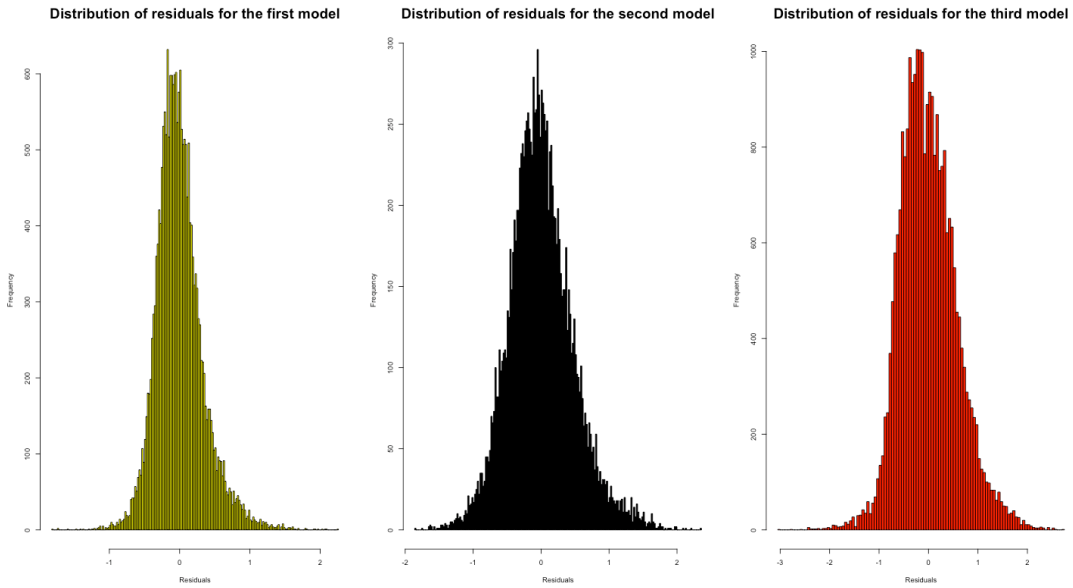
Before staring interpreting the coefficients, important thing to do is to test for heteroskedasticity. In short, heteroscedasticity is when, the variance of $\varepsilon_t$ at fixed independent variables is not constant. What is the danger of heteroscedasticity? The problem lies in standard errors. These standard errors are untenable. That is, even with a large number of observations, the variance of the estimate is estimated incorrectly. This leads to the fact that it is impossible to build confidence intervals for the forecast (Basic Econometrics Damodar N. Gujarati, Chapter 11).

The Brousch-Pagan test was used to check for heteroscedasticity. This test consists of the following: in addition to evaluating the main regression, an auxiliary regression is estimated, where the dependence of the squared residuals of $\varepsilon_t$ on those explanatory variables as in the original model is checked. Due to the very small p-value, the hypothesis of conditional homoscedasticity was rejected, that is, the problem of heteroscedasticity is present in our sample. In this case, we need to use other standard errors that are robust to heteroscedasticity. This can be done using Robust Standard Errors (Halbert White 1980). The 'sandwich' library from R was used to do this.

A Jarque Bera Test was also performed to verify whether skewness and kurtosis of the model's residuals correspond to the expected values for the normal distribution. The 'tseries'

library from R was used to do this. In all cases, we reject the hypothesis about normal distribution due to very low p-value. Take a look at the histograms below (Figure 11).

Figure 11. Distribution of residuals for three models



# CHAPTER 4. DATA

## 4.1. Source of data

Data for analysis were parsed from auto.ria.com. The R programming language and the 'rvest' library were used to write the parser. The parsing algorithm is structured as follows:

- collecting links to all advertisements on used cars;
- passing through each advertisement on the link;
- parsing the necessary data and creating the full dataframe.

The data was parsed according to the following categories: Link to advertisement, Price (in UAH), Brand, Model, Year of manufacture, Mileage, Drive, Body, Color, Fuel type, Capacity, Transmission, Comfort (which makes this car stand out in the context of comfortable conditions), Audio system , Accident (whether there was an accident or not), the City in which the car is sold, Vehicle status (whether the car is in a garage storage, whether the car has a service book, whether the car is individually equipped), Owners (quantity), Technical condition, Clearance status, Varnish condition, Safety attributes, VAT (VAT (the price of the car is indicated with or without VAT) and Description (the owner describes this car in his own words and prescribes his conditions).

## 4.2. Data cleaning

The initial data was information on 157 333 advertisements for used cars. But, of course, a lot of dirty work has been done to cleanse in order to prepare the data for analysis with the highest quality. This was done using the R programming language. So, what was done:

1. Those advertisements that were offered by non-cleared cars were eliminated. This is very important, because the price of a car, in such cases, is much lower, since it does not include the costs of official registration;

2. Removing or transforming incorrect data that was detected by filtering. For example, the site assumes that the mileage must be indicated in thousands of km, but there were such announcements where the mileage was indicated in the usual format (for example, instead of 3, which means a mileage of 3000 km, 3000 was written);
3. Advertisements that include VAT in the price have also been removed. They tend to be more expensive.
4. Deletion of data placed by NA;
5. Removal all body types except Liftbacks, Minivans, Crossovers, Station wagons and Sedans.
6. Removal all fuel types except Diesel and Gasoline for the first model.
7. Removal of all brands that strongly correlate with one of the aforementioned fuels.

Also, based on some variables, other variables were created:

I. Age – 2022 minus the year of manufacture of the car;
II. Oblast – based on information about the city or town from which the car is. Due to this variable we could create variable Part, which groups the oblasts depending on the region of the country in which they are located (South, North, West, East or the capital of Ukraine Kiev).
III. Individual equipment – with the help of text mining, this variable was created on the basis of vehicle condition, which indicates whether the car is individually equipmented or not.
IV. Service book – with the help of text mining, this variable was created on the basis of vehicle condition, which indicates whether the car has service book or not;
V. Garage storage – with the help of text mining, this variable was created on the basis of vehicle condition, which indicates whether the car was stored in the garage or not;
VI. Dummy mileage – shows whether the car mileage more or less than 100,000 km;
VII. Average annual mileage – mileage divided by age of the car. This is a very important indicator when choosing a car. Experts note that the best option when buying a used car is if it drives no more than 15,000 - 25,000 km per year (depending on the type of fuel).

VIII. Curve – was created on the basis of Average annual mileage, it the deviation from rate of the average annual vehicle mileage. For example, for cars with a gasoline engine, the annual rate is 15,000 km, for diesel - no more than 25,000 km. Logically, this deviation has a non-linear relationship with the price. The most suitable option for graphic perception is to introduce this variable under cube root.

IX. Slope – was created on the basis of Curve, shows the deviation of the above variable is less than zero or greater than zero;

X. Fuel100k – this dummy variable was made for each fuel type. For example, 1 if the fuel type is "Diesel" and the total mileage of the vehicle is up to 100,000 km, otherwise 0.

The idea of using the last 5 variables was taken from "Using a hedonic price model to test prospect theory assertions: The asymmetrical and nonlinear effect of reliability on used car prices" (2014) Marc Prieto, Barbara Caemmerer and George Baltas.

### 4.3. Data description

So, after all the manipulations, the removal of unnecessary information, the final data amounted to 20 884 observations on used cars. The first model data includes the following variables: see Table 5.

Table 5. Summary statistics and description of variables (first model)

| Variable | Min. | Max. | Mean | SD | Description |
|---|---|---|---|---|---|
| Body | | | | | |
| *Sedan* | 0 | 1 | 0.27 | 0.44 | Dummy equal to 1 if the car is one of these body type, 0 otherwise |
| *Crossover* | 0 | 1 | 0.22 | 0.41 | |
| *Wagon* | 0 | 1 | 0.34 | 0.47 | |

Continuation of Table 5.

| | | | | | |
|---|---|---|---|---|---|
| *Hatchback* | 0 | 1 | 0.16 | 0.37 | |
| **Technical condition** | | | | | |
| *Professionally repaired damage* | 0 | 1 | 0.21 | 0.40 | Dummy equal to 0 if there is no damage or previously repaired damage, 1 otherwise |
| *Completely undamaged* | 0 | 1 | 0.78 | 0.40 | |
| **Fuel** | | | | | |
| *Gasoline* | 0 | 1 | 0.5 | 0.5 | Dummy equal to 1 if the car uses one of these fuel type, 0 otherwise |
| *Diesel* | 0 | 1 | 0.5 | 0.5 | |
| **Quantity variables** | | | | | |
| *Age* | 1.09 | 3.55 | 2.33 | 0.45 | Logarithmic Age of the car |
| *Price* | 9.76 | 15.2 | 12.5 | 0.59 | Logarithmic Price of the car |

It is worth noting that some variables were not used due to the unrepresentativeness of the sample. For example, the previously created variable Part. The fact is that the

distribution of the number of cars by regions is not even approximately uniform, so the use of this variable makes it impossible to qualitatively interpret. Also, before data cleaning, the type of fuel was highly correlated with the age of the car. That is, on average, gasoline engines were older than diesel. That is why the number of all cars was evenly distributed between the type of fuel and age values. After these actions, the coefficients became more correct. This is the difficulty of using Dummy variables.

In this case, due to the unrepresentativeness of the sample, problems with multicollinearity may arise. As in the case of variable Part, some body types were removed, the number of which is completely different from those in the model. Experts note that the percentage of each category should not be less than 15%. Since the purpose of this study is not a comprehensive assessment of all the technical characteristics of cars, but only to test the above hypotheses, models were built only with key variables. In the first model, the key variables are Age, Fuel type and Body. In the second model – variable Curve is key.

In the third model, the intersection of the fuel type with mileage exceeding the 100 thousand limit is already directly related to hypothesis №1.

The final data for the second model amounted to 13 723 observations on used cars. If the first model did not use the Gas / Gasoline type of fuel through the correlation with the Age variable (on average, cars with this type of fuel are older than gasoline or diesel), then in this case it was included in the dataset as additional observations. It is important to clarify that the number of observations for this model is less for the following reason: since our key variable is the Curve variable, which, in fact, shows deviations from the average annual mileage, it was decided to use the Slope variable to look at the age of cars in the context of or deviations are positive or negative. After that, it was decided to make the sample more representative by balancing the average age of the cars, the Curve indicator which is less or more than the norm. This was done to avoid an incorrect sign in front of the coefficient in the model. The fact is that age, judging by the results of the first model, is a very strong factor influencing the price, and therefore, when the average age of cars in which the deviation of this indicator is negative, the model can show that the increasing of indicator leads to a decrease in the price. Also, since the Transmission variable was also

used, all other types of gearboxes were removed except Automatic and Mechanics, since the percentage of each was too small. So, the second model data includes the following variables: see Table 6.

Table 6. Summary statistics and description of variables (second model)

| Variable | Min. | Max. | Mean | SD | Description |
|---|---|---|---|---|---|
| **Transmission** | | | | | |
| *Automatic* | 0 | 1 | 0.55 | 0.49 | Dummy equal to 1 if the car is one of these transmission, 0 otherwise |
| *Mechanics* | 0 | 1 | 0.44 | 0.49 | |
| **Garage storage** | | | | | |
| *Garage storage* | 0 | 1 | 0.49 | 0.49 | Dummy equal to 1 if the car was stored in the garage, 0 otherwise |
| *Not Garage storage* | 0 | 1 | 0.5 | 0.49 | |
| **Quantity variable** | | | | | |
| *Curve* | -4.08 | 2.85 | 0.02 | 1.6 | The deviation from rate of the av. annual mileage under cube root |

The final data for the third model amounted to 26 536 observations on used cars. It also contains data on cars that use Gas / Gasoline type of fuel. Only in this case, this type of fuel acts as one of the key variables. So, the third model data includes the following variables: see Table 7.

Table 7. Summary statistics and description of variables (third model)

| Variable | Min. | Max. | Mean | SD | Description |
|---|---|---|---|---|---|
| **Individual equipment** | | | | | |
| *Individual equipment* | 0 | 1 | 0.13 | 0.33 | Dummy equal to 1 if the car is individually equipmented, 0 otherwise |
| *Not Individual equipment* | 0 | 1 | 0.86 | 0.33 | |
| **Fuel100k** | | | | | |
| *Gasoline100k* | 0 | 1 | 0.39 | 0.48 | Dummy equal to 1 if the car uses one of these fuel type and total car mileage is up to 100,000 km, 0 otherwise |
| *Gas/Gasoline100k* | 0 | 1 | 0.21 | 0.41 | |
| *Diesel100k* | 0 | 1 | 0.39 | 0.48 | |
| **Service book** | | | | | |
| *Service book* | 0 | 1 | 0.34 | 0.47 | Dummy is 1 if the car has service book, 0 otherwise |
| *No Service book* | 0 | 1 | 0.65 | 0.47 | |

# CHAPTER 5. RESULTS

## 5.1. First model

Table 8. Summary of the results of the first model

| Variable | Coefficient | Std. Error | P-value |
|---|---|---|---|
| *logAge* | -0.824754 | 0.0064354 | *** |
| **Body type: *Sedan* is a base category** | | | |
| *Crossover* | 0.334764 | 0.0081274 | *** |
| *Station Wagon* | -0.237082 | 0.0068525 | *** |
| *Hatchback* | -0.330263 | 0.0072797 | *** |
| **Technical condition: *Completely undamaged* is a base category** | | | |
| *Professionally repaired damage* | -0.128959 | 0.0069490 | *** |
| **Fuel type: *Gasoline* is a base category** | | | |
| *Diesel* | 0.121189 | 0.0052804 | *** |

The results of the above model state a strong negative influence of the age of used cars on their price. More precisely, the price can be interpreted as follows: for example, an additional year reduces the price of a car by about 57% for a one-year-old car (ceteris paribus). How it was calculated: we need to multiply the coefficient of log (Age), which came out in the model, by the difference between ln (2) and ln (1). If we talk about older

cars, then, for example, for a seven-year-old car, an additional year reduces the price by almost 11% (ceteris paribus).

If we talk about body types: on average, the most expensive cars are, in this case, Crossovers, the cheapest are Hatchbacks. Hatchbacks are on average about 29% cheaper than a sedan, Station Wagons - 21%, and Crossovers are 39% more expensive (ceteris paribus). How it was calculated: we have to bring the exponent to the power, which in the model is in the form of a coefficient near the variable.

About technical condition: if the car has already been repaired, even if it was really professionally done, then on average such a car already loses in price by about 12% (ceteris paribus).

If we talk about fuel types: on average, diesel cars are 12% more expensive than gasoline cars (ceteris paribus).

### 5.2. Second model

Table 9. Summary of the results of the second model

| Variable | Coefficient | Std. Error | P-value |
|---|---|---|---|
| *Curve* | 0.0225811 | 0.0025363 | *** |
| **Transmission: *Mechanics* is a base category** | | | |
| *Automatic* | 0.6855296 | 0.0080717 | *** |
| **Garage storage: *Not Garage storage* is a base category** | | | |
| *Garage storage* | 0.0511813 | 0.0082391 | *** |

The results of the aforementioned model indicate a strong positive effect of the automatic transmission on the price of used cars, as well as, albeit a weak, but positive effect of the fact that the car was in the conditions of garage savings. In this model, the key

variable on which our second hypothesis is based is the Curve variable. Its specificity is that it is nonlinearly related to price, since it is represented as a cube root. In this case, it will not be advisable to interpret this variable as usual. Yes, to make things easier, we can say that an increase in the cubic root of deviation from the average annual mileage by 1, on average, is associated with a 2% increase in price, but for a more accurate interpretation, we can also use marginal effects. But in this case, in order to understand that our second hypothesis is rejected, one can do without it. Yes, the relationship is positive, that is, with an increase in this indicator, the price increases, but at the same time, the role of this variable in the formation of the price of a used car is rather small, which can be explained by the assumption that the average annual mileage is almost not paid attention to in the Ukrainian used car market.

### 5.3. Third model

Table 10. Summary of the results of the third model

| Variable | Coefficient | Std. Error | P-value |
|---|---|---|---|
| **Individual equipment: *Not Individual equipment* is a base category** | | | |
| *Individual equipment* | 0.2569540 | 0.0112201 | *** |
| **Service book: *No Service book* is a base category** | | | |
| *Service book* | 0.0776430 | 0.0073910 | *** |
| **Fuel100k: *Gasoline100k* is a base category** | | | |
| *Gas/Gasoline100k* | -0.3063284 | 0.0095152 | *** |
| *Diesel100k* | 0.1115642 | 0.0080200 | *** |

The third model includes such a key variable as Fuel100k. The first hypothesis is based on it. According to the results: cars that run on a Gas / Gasoline engine and which have overcome the mark of 100,000 km are cheaper than the same cars, only on a gasoline engine by about 26%. Diesel cars, which overcame the mark of 100,000 km, are more expensive than gasoline ones by 100,000 km. That is, the hypothesis that the diesel type of engine can slow down the price drop from the fact that the car has traveled more than 100,000 km has been confirmed.

Also based on the model: cars in the advertisement of which it is written that they are individually equipmented are on average 29% more expensive than others, as well as cars that have a service book on average are 8% more expensive.

# CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

This study aimed to make a complete analysis of the used car market in Ukraine. Were analyzed:

- the most popular online platforms for buying and selling used cars (auto.ria.com, RST.ua, ab.ua, cars.ua, parkdrive.ua, automoto.ua, OLX / transport);
- the most popular platforms for buying cars from the USA and Europe (Atlanticexpress, Americanavto, Columbauto, Autoscout24, plc.ua, Autodealerr);
- trends in the used car market in Ukraine for the period from 2018 to September 2021 with the help of different visualizations and descriptive statistics;
- hedonic pricing models to test the hypotheses put forward.

The first hypothesis that a diesel engine type that has traveled more than 100,000 kilometers softens the price drop in comparison with other types of fuel (such as Gas / Gasoline and Gasoline) has been confirmed. This proves the fact that diesel engines are more durable.

The second hypothesis can be said to have been confirmed 50% to 50%. The positive deviation from the rate of average annual mileage has positive impact on the price, but at the same time it is very scanty, which was not expected when the hypothesis put forward.

Since this work includes an analysis of various online sites for buying and selling cars, as well as their social networks, which, of course, are important for the popularization of a particular platforms, it can be useful for the refreshing of the marketing policy of these intermediaries in the Ukrainian car market. For example, platforms such as RST.ua and OLX / transport can be advised to pay more attention to such social networks as Instagram and Facebook to promote their services, because the difference between RST.ua and auto.ria.com is huge, and for OLX, then it would be advisable to use a separate account on social networks (because currently there is only a general account that combines all the goods and services sold on OLX), which is dedicated only to the purchase / sale of cars. Anyway, looking at Table 1. (Statistics of the most popular auto platforms in Ukraine) and

Table 2. (Statistics of the most popular services for bringing used cars from the USA and Europe in Ukraine) platforms can study their competitive environment and understand their place in the market. Therefore, this information can push the players in this field to adjust their marketing plan to increase popularization.

If we give any recommendations based on the results of the model, then buyers whose goal is to purchase a car for driving over long distances can be advised to leave their choice on Diesel cars, since it was mathematically demonstrated that such cars are the most durable in price, and therefore in technical condition, rather than Gasoline engines or Gas / Gasoline.

Also, despite the fact that the Curve variable in the second model, which denotes the deviation from rate of the average annual vehicle mileage under cube root, showed a rather weak positive relationship with the price, we can advise both buyers and sellers to use this indicator when bargaining. Thus, the buyer can reduce the price of the car when buying, and the seller, in turn, can increase it if his car is compared to an identical model, but at the same time with a much worse average annual mileage.

This work may also be interesting to ordinary car enthusiasts, who will be able to visually see how things are coming on the market of used cars in Ukraine: which brands, which models are the most popular both in terms of regions and in terms of origin (either a Ukrainian car, or brought from abroad) etc.

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