Impact of ICT on Development of Automotive Industry

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Faculty of Economics and Business

Master in Managerial Informatics

Impact of ICT on Development of Automotive Industry

Master Thesis

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Zagreb, September 2020

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Contents

1. Introduction

An important cognition to have in mind while approaching this thesis is that personal vehicles, specifically cars are objects of great financial value, which makes a big difference in the approach of consumers. Unlike the approach of purchasing an accessory such as sunglasses or shoes where consumers can be quite pliable and rash when making a decision, cars are products that the consumer will own somewhere in the range of five to ten years and will have to invest approximately a year worth of salaries. In this situation any rational buyer will think twice about going for a 7- or 10-inch display, since car parts are drastically overpriced. Knowing this, retailers can gain a significant advantage by analysing sales data in order to tailor their assortment according to the buyers needs and wishes.

There are many points of pressure being placed upon manufacturers and retailers alike that will inevitably instigate changes in their business models. The European Union is pushing more and more regulations and policies regarding fuel consumption and carbon dioxide emissions; public transportation is becoming more and more convenient; various taxi services are improving their services with the competition putting pressure on prices; car-sharing and car-pooling models and emerging and becoming more prominent in Europe.

Automotive industry has taken some big turns in the last 5-7 years with the goal of reducing the negative effects on the environment that it inherently leaves. There is an ongoing inception of a new trend where consumers are starting to realize the benefits of electric vehicles and switch to them. However, this evolution of personal vehicles would not be possible without all the ICT support enabling new features and functionalities.

It is common knowledge that consumers in Croatia have different preferences when purchasing personal vehicles and the research done for this thesis will try to objectify and quantify that knowledge.

1.1. Topic and Goals of the Thesis

The automotive industry has long surpassed the stage where pistons, engine displacement and carburettors were the only factors. In this day and age, majority of vehicles have the same two or three engines and everything else depends on modern technology and the usage of ICT systems. In fact, electric vehicles are making their entrance into the European market with the battery technology still in development, with much room for improvement. On today’s automotive market the real dealbreaker when it comes to making a sale are ICT features the car can offer. This thesis will emphasise on explaining the usage of those tech features in modern vehicles, such as advanced systems for adaptive cruise control, emergency braking, parking cameras and sensors, smartphone integration, infotainment, self-parking and all the way to full autonomy. However, every additional piece of equipment brings about more complexity and added costs and maintenance. Because of that, advantages and disadvantages of ICT usage will be broken down and explained. Furthermore, Croatian car market, although completely reliant on the European market, differs in many aspects, which will be investigated in this thesis.

In this thesis, development of automotive industry will be presented as well as future trends regarding usage of latest ICT trends in automotive industry. The purpose of thesis is to present influence of the ICT on development of the automotive industry. Beside theoretical framework, statistical data collected from Eurostat about automotive industry in Europe will be presented. CVH (Centar za Vozila Hrvatska) also provide data on vehicles in the M1 category from 2019 which will give an overview of average age of vehicles, average CO2 emissions and average price in Croatia. This information will provide detailed statistics on the current state of the automotive industry mainly in the EU and a comparison with Croatia.

The goal of the thesis is to determine the impact of ICT on development of automotive industry. A questionnaire will be conducted in order to investigate respondents' preferences when purchasing a vehicle especially regarding ICT application and to determine which technology is used the most in the automotive industry in Croatia.

1.2. Explanation of Methodology

In order to achieve research goal, literature review regarding automotive industry and impact of ICT to automotive industry will be presented. In addition, descriptive analysis will be applied to analyse collected data. Data will be collected via online questionnaire in order to investigate respondents' preferences when purchasing a vehicle especially regarding ICT application and to determine which technology is used the most in the automotive industry in Croatia. Questionnaire consists of following parts: (i) respondents' demographic characteristics; (ii) respondents' preferences when purchasing a vehicle (brand, price, age, co2, …); (iii) respondents' preferences regarding technology usage in vehicle; (iv) respondents' opinion regarding ICT trends in automotive industry. Survey will be distributed via Internet, social media and online forums. The survey was carried out on a sample of Croatian citizens who are Internet users.

1.3. Structure of the Thesis

The first chapter is Introduction which will include description of Topic and Goal of the Thesis. Furthermore, Data and Methodology will be presented. At the end of the Introduction, Structure of Thesis will be described.

The second chapter is Automotive Industry. This chapter will include description of Development of the Automotive Industry, market Trends of Automotive Industry and statistics Review of the Automotive Industry. In the last subsection of the second chapter, statistics data for EU and Croatia market regarding automotive industry will be presented.

The third chapter is about the Impact of ICT on Automotive Industry. This chapter will start off by explaining the Application of ICT in Automotive Industry, followed by a breakdown of Advantages and Disadvantages of ICT Impact on Automotive Industry. The last subsection of the third chapter will present Future Trends of ICT Usage in the Automotive Industry, divided into three subsections about Electric Vehicles, Autonomous Vehicles and Application of "Internet of Things" in Automotive Industry.

The fourth chapter is Analysis of Research Results regarding ICT Usage in Automotive Industry, where the sub-chapters will explain and present the Research Methodology, Research Results followed by a Discussion.

After this, a Conclusion will be brought forth. Followed by the final three chapters, which are List of References, List of Graphs and Tables and the Appendix.

2. Automotive Industry

2.1. Development of the Automotive Industry

Many individuals throughout history can be credited with some sort of an idea for a self-propelled personal passenger vehicle. The idea occurred to Homer while writing the Iliad where he stated that Vulcan had made some kind of self-moved tricycles; Leonardo da Vinci also proposed an idea in the 15th century; in 1760 a Swiss clergyman thought it clever to mount small windmills to a cart. Most historians will, however, agree that Nicolas-Joseph Cugnot, a French military engineer, contracted the first "true" automobile. All of this is not very relevant to this thesis, and this chapter will focus on major developments after the invention of the internal combustion engine, more precisely, since Henry Ford's assembly line started rolling in 1913.

Although, the entire industry and a large part of the todays world can be thanked to Karl Benz or Gottlieb Daimler for the invention of the internal combustion engine and the four-stroke cycle, based on which to this day vehicles are constructed, the real inception to the automotive industry started with Ford's assembly line.[1] In 1913, Henry Ford came up with an idea for the first moving assembly line for mass production. He took inspiration for this concept from the continuous-flow production methods used by flour mills, breweries, canneries and industrial bakeries. This concept reduced the time it took to build a car from over 12 hours to just two and a half hours, which is more than a quadruple time reduction without even considering the cost reduction and increase in efficiency. His model T was in no way an exquisite product, it was in fact simple, sturdy and cheap. His business idea was not based on the vehicle itself but on perfecting the efficiency at which his workers could assemble the vehicles. From the introduction in 1913 to 1914 his factory produced and sold 10 million cars to the public.[2]

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[1] Purdy, K., W., Foster, C., G., Britannica: History Of The Automobile https://www.britannica.com/technology/automobile/History-of-the-automobile

[2] History.com (2009): Ford's assembly line starts rolling https://www.history.com/this-day-in-history/fords-assembly-line-starts-rolling#:~:text=On%20December%201%2C%201913%2C%20Henry,two%20hours%20and%2030%20minutes.

2.2. Market Trends of the Automotive Industry

This chapter will break down the most significant trends in the automotive industry in the recent years, which is important for analysis of the Croatian market since it is completely dependent on EU regulations and foreign manufacturers, which are also mostly European.

It was shown in the previous chapter how the amount of funding pumped into research and development has constantly been rising for the past 10 years and it can only be expected that that trend will continue, only in greater numbers. Encouraged by Tesla's emergence on the market, many other manufacturers have been dabbling in electric vehicles recently. BMW released their sporty and expensive hybrid i8 model in June 2014 and their every-day fully electric i3 model in July 2016. Volkswagen have their e-Golf and e-Up fully electric versions, the Golf from 2014 and Up from last year, 2019. However, the fully electric trend is picking up and Volkswagen decided to release a whole new electric model named ID.3. The name of the model represents the third model in history to mark a new direction of their identity, first one being the Beetle in the 50s, followed by the Golf in the 70s.

However, looking at this chart, provided by acea.be it is obvious that only 3.4% of all passenger cars in Europe are not powered by either diesel of petrol (Figure 1).

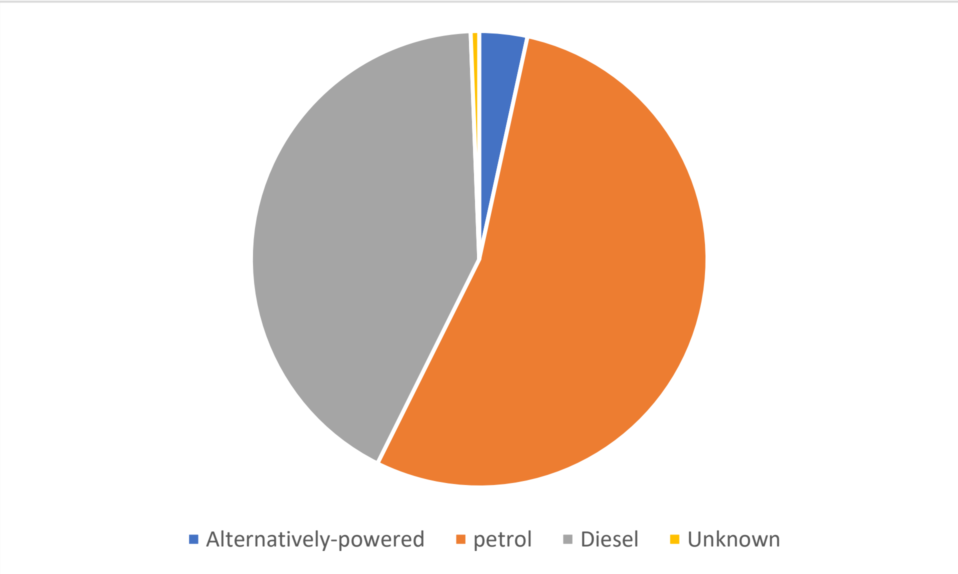

Figure 1: Distribution by fuel type (Source: acea.ne)

This chart can even be broken down into more detail with data taken from Statista, where the distribution of fuel types in European countries can be observed (Table 1). Aside from Norway, Netherlands and France no countries have over 4% share of electric cars. Norway setting the bar very high at 50.52%.

	Petrol	Diesel	Battery electric	Hybrid	APV other	Plug in hybrid
Austria	46.13%	38.99%	4.45%	8.07%	0.19%	2.17%
Czechia	63.97%	28.46%	1.66%	4.08%	0.92%	0.90%
France	48.70%	33.18%	7.12%	8.26%	0.16%	2.58%
Germany	51.25%	31.94%	3.71%	9.00%	0.33%	3.77%
Ireland	38.13%	43.81%	3.31%	12.68%	0.00%	2.06%
Italy	45.03%	34.11%	1.55%	10.00%	8.46%	0.85%
Netherlands	71.81%	5.30%	8.43%	11.18%	0.11%	3.17%
Romania	60.99%	29.68%	0.97%	8.03%	0.33%	0.00%
Slovakia	64.38%	26.29%	0.88%	7.03%	0.59%	0.83%
Slovenia	60.91%	33.82%	2.93%	2.84%	0.03%	0.00%
Spain	54.88%	27.29%	1.81%	13.45%	1.07%	1.51%
EU	52.30%	29.91%	3.72%	9.42%	1.60%	3.05%
Norway	9.50%	10.79%	50.52%	9.96%	0.00%	19.23%
United Kingdom	60.39%	18.91%	3.78%	14.11%	0.00%	2.83%

Table 1: Distribution by fuel type per country (Source: acea.be)

It can also be noticed that in all countries except Ireland, the majority of people drive petrol cars. This fact will be useful in the later chapter when the data in Croatia is introduced. Ireland is the only country on this list that has more diesel cars than petrol cars. Here is the data shown from the table illustrated in a graph (Figure 2)

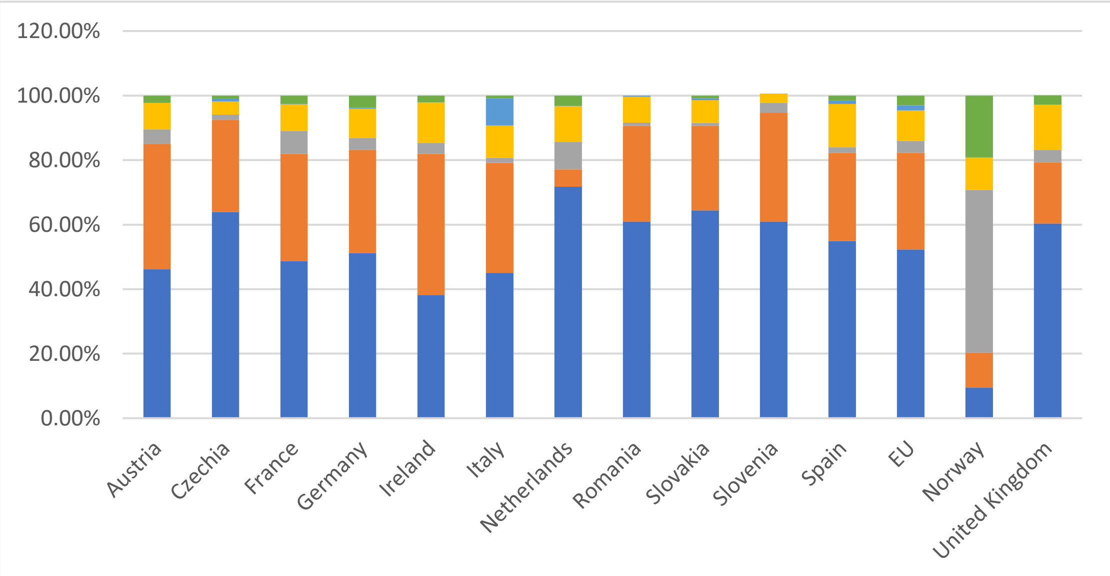

Figure 2: Distribution by fuel type per country (Source: acea.be)

2.2.1. Statistics Data for European Market

According to a paper for the European Commission, by Egil Juliussen and Richard Robinson, the automotive industry is a major European manufacturing and service industry and is one of the backbones of the European economy. The following table will show the statistics presented by the European Automobile Manufacturers' Association (ACEA) (Table 2).

	Key Information	Other Information
Employment	Direct jobs: 2.2 million Total jobs: 12.1 million	6.5% of manufacturing jobs 6% of all jobs
Revenue	Worldwide: €551 billion	ACEA members
R&D Investment	Europe: €20 billion Worldwide: €40 billion	4% of sales 7% of sales
Automotive production	19.7 million vehicles 17.1 million passenger vehicles	Cars, vans, trucks, buses 27% of worldwide total
Exports	€42.8 billion net trade	Leading EU export industry
Vehicle taxes	€281 billion in government revenue	3.5% of European GDP

Table 2:State of auto industry for EU, year 2007 (Source: acea.be)

This table (Figure 2) is taken from the year 2007 and it shows us that 2.2 million jobs are provided directly by manufacturers, while 12.1 million people are employed in the automotive industry indirectly, 551 billion euros of total revenue was produced, 17.1 million passenger cars were produced and 40 billion euros were invested in research and development. The automotive industry has contributed with 3.5% of the entire European GDP which is 381 billion euros. The automotive industry is EU's leading export industry.[3]

[3] European Automobile Manufacturers Association (2020): The Automobile Industry Pocket Guide

Now, this table from 2018. /2019. can be taken and compared with 11/12 years' time in between. (Table 3)

Employment	
Manufacturing of motor vehicles (EU)	2.7 million people = 8.5% of EU employment in manufacturing
Production	
Total (EU manufacturing, services and construction)	14.6 million people = 6.7% of total EU employment
Motor vehicles (world)	92.8 million units
Motor vehicles (EU)	18.5 million units = 20% of global motor vehicle production
Passenger cars (world)	74.2 million units
Passenger cars (EU)	15.8 million units = 21% of global passenger car production
Trade	
Motor vehicle exports (extra-EU)	€135.9 billion
Motor vehicle imports (extra-EU)	€62.0 billion
Trade surplus	€73.9 billion
Environment	
Average CO2 emissions new cars (EU)	123g CO2/km
R&D Investment	
Automotive R&D investment	€60.9 billion
Vehicle taxes	
Fiscal income from motor vehicles	€440.4 billion

Table 3:State of auto industry for EU, year 2019 (Source: acea.be)

It can be observed that direct employment provided by the automotive industry increased by 2% and total employment increased by 0.7%. Furthermore, an increase of 50% is visible in research and development and revenue increased from 381 billion euros to 440.4 billion euros which is a 15% increase. Interestingly, a decrease in production is noticeable which can be connected to the claim made in the introduction of the thesis regarding the pressures placed upon the manufacturers.

Table 4 will show the number of employed people in different sectors of the industry. Direct manufacturing encapsulates jobs in: motor vehicles, bodies (coachwork), trailers and semi-trailers and parts and accessories. Indirect manufacturing represents jobs in: Rubber tyres and tubes, rethreading and rebuilding tyres; computers and peripheral equipment; electric motors, generators and transformers; bearings, gears etc; cooling and ventilation equipment. Automobile use represents jobs in: sales, maintenance, sales of parts and accessories, sales of fuel, renting and leasing. Construction represents jobs in construction of roads, motorways, bridges and tunnels. The Table 4 will show these numbers for years 2014-2018.

EU automotive employment	**2014**	**2015**	**2016**	**2017**	**2018**	**% change 18/17**
Direct manufacturing	2,369,951	2,441,910	2,491,693	2,597,345	2,685,478	3.39%
Indirect manufacturing	892,885	910,004	899,647	958,152	967,925	1.02%
Automobile use	4,264,490	4,304,382	4,453,169	4,531,379	4,657,198	2.78%
Transport	4,980,618	5,047,587	5,229,789	5,390,441	5,591,549	3.73%
Construction	641,931	675,338	650,011	705,199	727,230	3.12%
TOTAL	**13,149,875**	**13,379,221**	**13,724,309**	**14,182,516**	**14,629,380**	**3.15%**

Table 4: EU automotive employment 2014-2018 (Source: acea.be)

It can be observed that in every of these fields of employment, year after year there is a steady increase in the number of jobs. The key field for this thesis is indirect manufacturing as it contains the jobs on development of on-board computers and various other tech. The increase from 2017 to 2018 is actually the smallest which is why the percentage change in every year and a total change from 2014 to 2018 should be observed. (Table 5)

Year	**% change in indirect manufacturing**
18/17	1.02%
17/16	6.50%
16/15	-1.14%
15/14	1.92%
18/14	8.40%

Table 5: Percentage change in indirect manufacturing employment (Source: acea.be)

Surprisingly there is a decrease in employment in indirect manufacturing in 2016 in regards to 2015. One possible reason for this atypical decrease could be the diesel emissions scandal in the third quarter of 2015 and the first quarter of 2016 where many car manufacturers had been caught dabbling with their numbers, such as: Renault, Nissan, Hyundai, Fiat, Volvo and others.

Many manufacturers had to pay large fines and subsequently cut costs by laying off workers.[4] A large sudden increase from 2016 to 2017 can also be observed, which can be attributed to the fact that 2017 and late 2016 were big years for new model releases and existing model facelifts. The number of employees in indirect manufacturing increased by 8.4% from 2014 to 2018.

The total increase in employment in those 4 years is 11.25%. The following chart (Figure 3) will display the data:

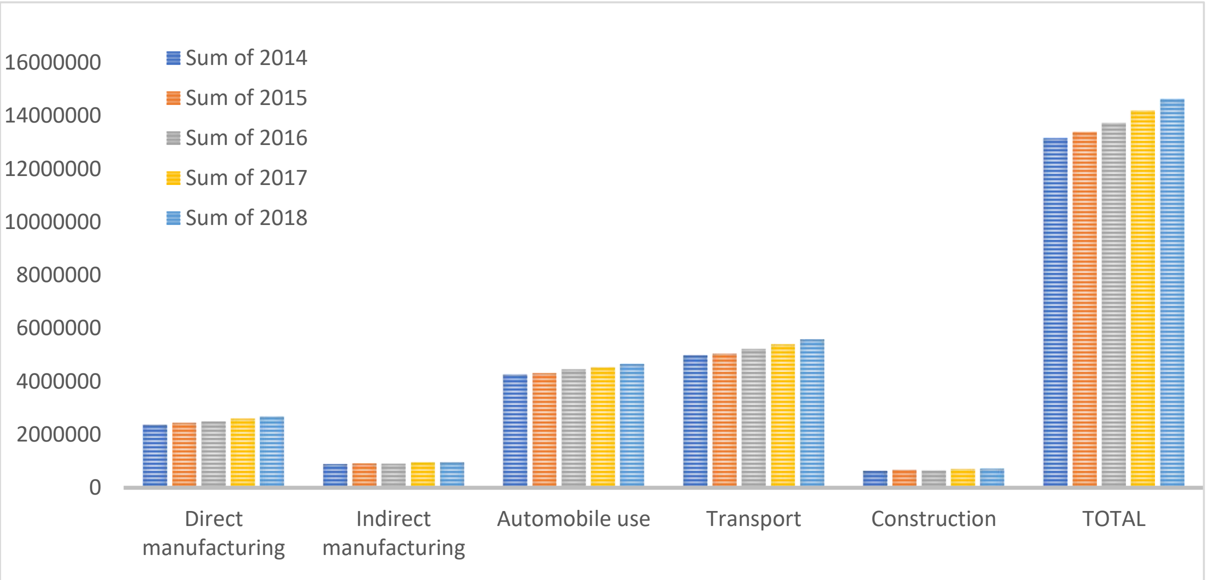

Figure 3: EU automotive employment 2014-2018 (Source: acea.be)

The following table (Table 6) shows that Croatia's part in the direct manufacturing employment is 1.1%, which is higher only than Greece and Cyprus at 0.5%[3]

Austria	39,569	Estonia	2,880	Italy	176,303	Slovakia	81,273
Belgium	28,768	Finland	10,199	Latvia	2,317	Slovenia	15,887
Bulgaria	23,777	France	229,422	Lithuania	6,163	Spain	162,634
Croatia	2,919	Germany	882,046	Netherlands	25,204	Sweden	90,473
Cyprus	168	Greece	1,737	Poland	213,708	United Kingdom	166,228
Czech Republic	181,415	Hungary	101,865	Portugal	42,358	European Union	2,685,478
Denmark	4,317	Ireland	3,000	Romania	190,848		

Table 6:Croatian direct manufacturing employment (Source: acea.be)

[4] Carrington, D., The Guardian (2015): Wide range of cars emit more pollution in realistic driving tests, data shows https://www.theguardian.com/environment/2015/sep/30/wide-range-of-cars-emit-more-pollution-in-real-driving-conditions-tests-show

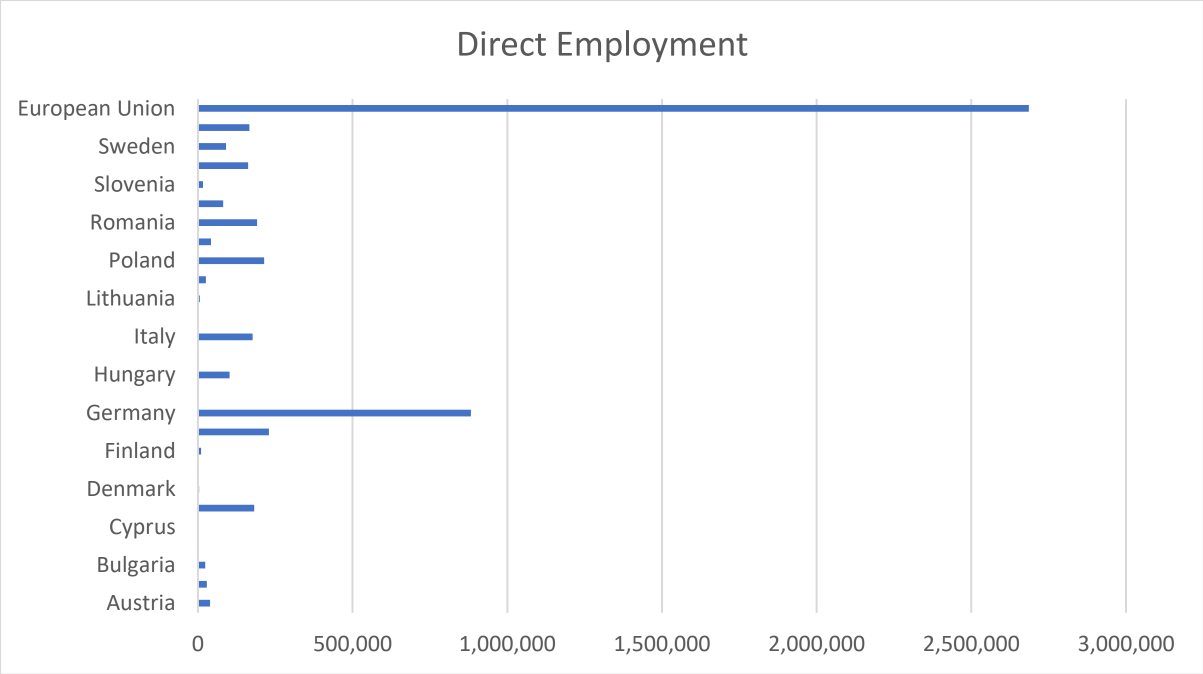

Figure 4: Direct employment EU per country (Source: acea.be)

This chart (Figure 4) displays direct employment numbers per country in the European Union. As expected, Germany has by far the biggest number of workers directly employed in the automotive industry and it makes up for 32.85% of the entire European Union.

2.2.2. Statistics Data for Croatia

This subchapter will analyse the data provided by Centar za Vozila Hrvatska (CVH). The data provided by them is for the year 2019. for the M1 category (passenger automobiles), as well as some data taken off their official website. Here is a table (Table 7) containing the information on every new registered passenger vehicle in Croatia in 2019. The first thing to point out here is that the ten most popular car makes in Croatia are in order: Volkswagen, Renault, Opel, Škoda, Peugeot, Dacia, Suzuki, Hyundai, Fiat and finally Toyota. The rest of car makes are denoted in the "Other car makes total" row.

Car Make	Number of Vehicles	Average Year of Production	Average Age	Average CO2	Average Purchase Price (HRK)
VOLKSWAGEN	8579	2018.98	0.02	117.36	176,234.61
RENAULT	6043	2018.86	0.14	117.26	123,849.10
OPEL	5801	2018.96	0.04	125.08	138,003.45
ŠKODA	5763	2018.99	0.01	118.01	168,864.04
PEUGEOT	3705	2018.86	0.14	109.72	152,057.60
DACIA	3687	2018.86	0.14	124.62	108,005.43
SUZUKI	3670	2018.89	0.11	123.26	124,956.99
HYUNDAI	3161	2018.65	0.35	121.53	126,466.41
FIAT	2687	2018.88	0.12	125.30	97,464.83
TOYOTA	2615	2018.84	0.16	100.79	149,422.60
OTHER CAR MAKES TOTAL	18638	2018.79	0.21	125.05	221,685.39
TOTAL	**64349**	**2018.87**	**0.13**	**120.51**	**165,323.48**

Table 7: Registration of new vehicles 2019 (Source: CVH)

The first column denotes the make of the vehicle, second is the number of vehicles, third denotes the average year of manufacture of that particular make, then there is the average age (which is in this table very low since all the vehicles are new), after that there is the average carbon-dioxide emissions and finally, average purchase price.

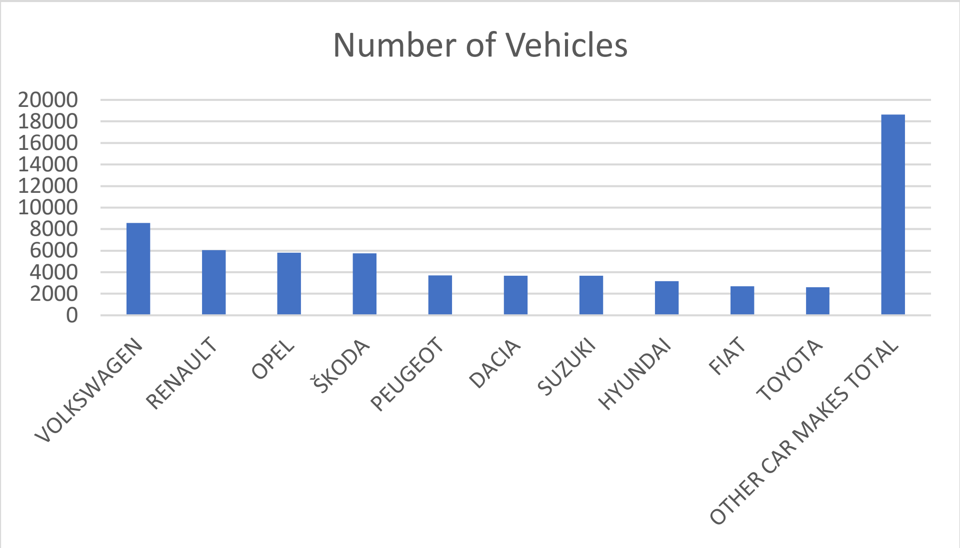

Figure 5: Number of new registered vehicles in 2019 (Source: CVH)

This graph (Figure 5) shows second row of the table, which is the quantity of registered vehicles for every make. It can be observed that Volkswagen is the obvious leader on the Croatian market. Volkswagen makes up for 13.33% of the total count of registered vehicles for 2019. If the fact that Škoda is owned by the Volkswagen group is taken into account and added to the count it would make up for 22.29% of all the vehicles. This is only in the top ten list, without Audi, Seat and Porsche and some other less significant makes. A grand total of 64,349 new vehicles have been registered in Croatia in 2019.

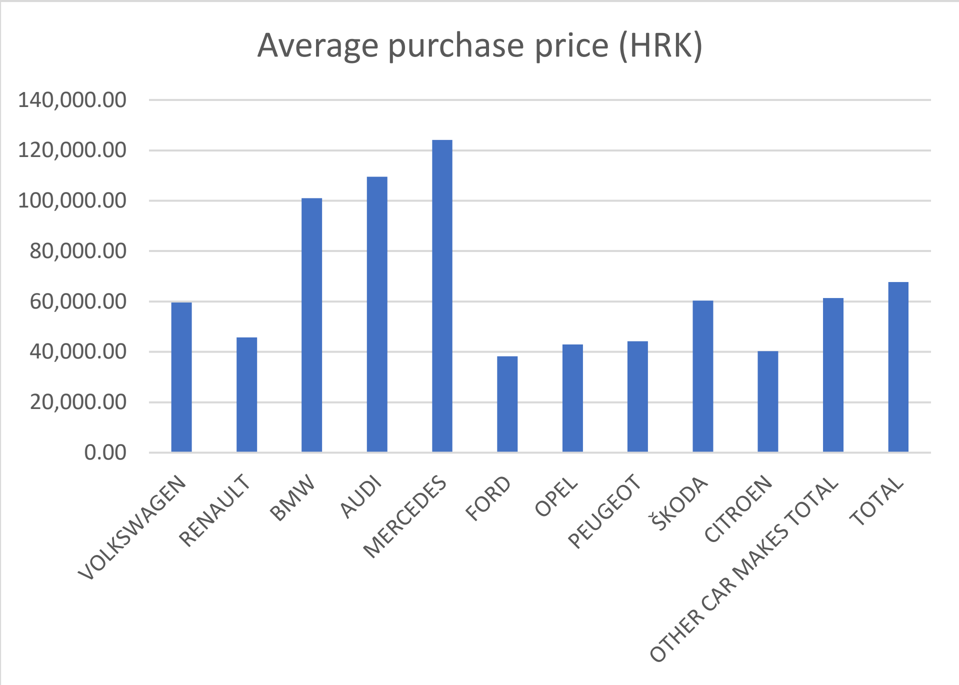

Figure 6: Average purchase price (HRK) (Source: CVH)

This is a graph (Figure 6) illustrating the average purchase price of new vehicles for the year. Volkswagen and Škoda are most prominent, but also most expensive on the list.

The column which represents the rest of car makes which don't make it on the top ten list is actually the highest regarding the price. This really makes sense since the more expensive vehicles are purchased rarely. This is also the reason why there aren't any big manufactures on this list like BMW, Mercedes, Audi, Alfa Romeo etc. Those makes are among the more expensive and luxurious.

The following graph (Figure 7) shows the average CO_2 emissions for every car make. They are all very much similar, with Toyota leading the top ten. This is because Toyota pushes

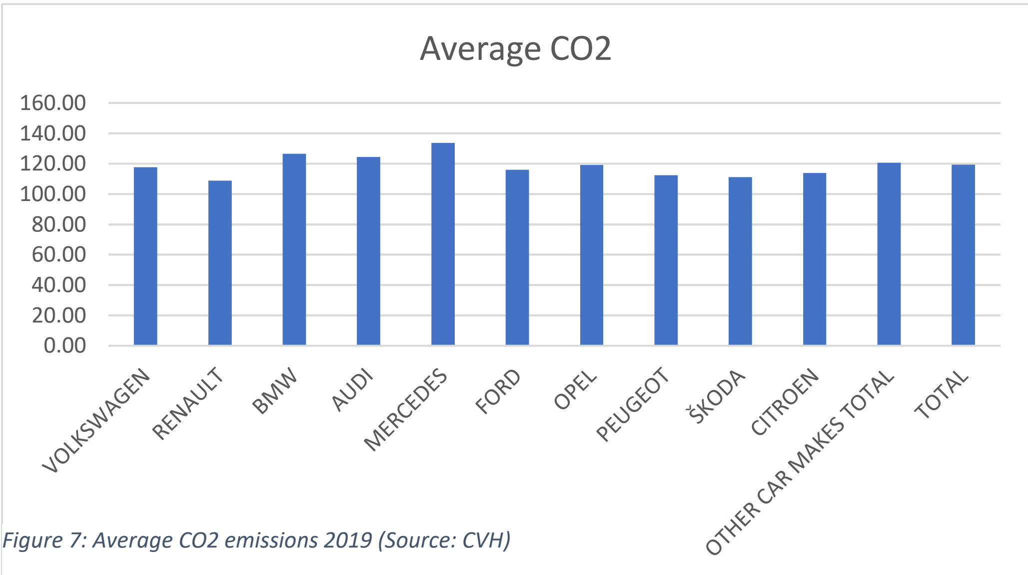

Figure 7: Average CO2 emissions 2019 (Source: CVH)

their hybrid and electric models as their major products and it is the business direction of the company. Average age of new vehicles will not be represented in a graph because that information isn't particularly relevant.

The following table (Table 8) will provide the same information as the previous one, but for used vehicles registered in 2019. A very important thing to note is that these are the vehicles registered for the first time in Croatia. This means that vehicles initially bought in Croatia and then sold in Croatia to the second owner will not make in on this table. This is, then, the list of vehicles that were imported in Croatia and registered in Croatia for the first time.

Car Make	Number of Vehicles	Average Year of Production	Average Age	Average CO2	Average Purchase Price (HRK)
VOLKSWAGEN	16623	2011.80	7.20	117.80	59,570.63
RENAULT	9019	2012.45	6.55	108.89	45,724.43
BMW	8549	2012.19	6.81	126.52	100,974.46
AUDI	7114	2012.66	6.34	124.37	109,503.10
MERCEDES	6427	2011.96	7.04	133.75	124,126.49
FORD	6333	2010.89	8.11	115.93	38,278.68
OPEL	5003	2011.72	7.28	119.13	42,998.36
PEUGEOT	4524	2011.94	7.06	112.39	44,228.01
ŠKODA	2635	2013.22	5.78	111.09	60,390.59
CITROEN	2430	2011.55	7.45	113.93	40,245.19
OTHER CAR MAKES TOTAL	16256	2011.48	7.52	120.61	61,372.28
TOTAL	**84913**	**2011.90**	**7.10**	**119.36**	**67,773.46**

Table 8: Registration of used vehicles 2019 (Source: CVH)

Right off the bat, it is apparent that Volkswagen is the most imported vehicle in Croatia, and by a large margin as well. Volkswagen is first with 16,623, ahead of Renault, which is second with 9,019. This table will be illustrated in the same graphs as the table for new cars, with the addition of a graph showing the average age for each make. This first graph (Figure 8) is showing the number of vehicles imported and registered in 2019.

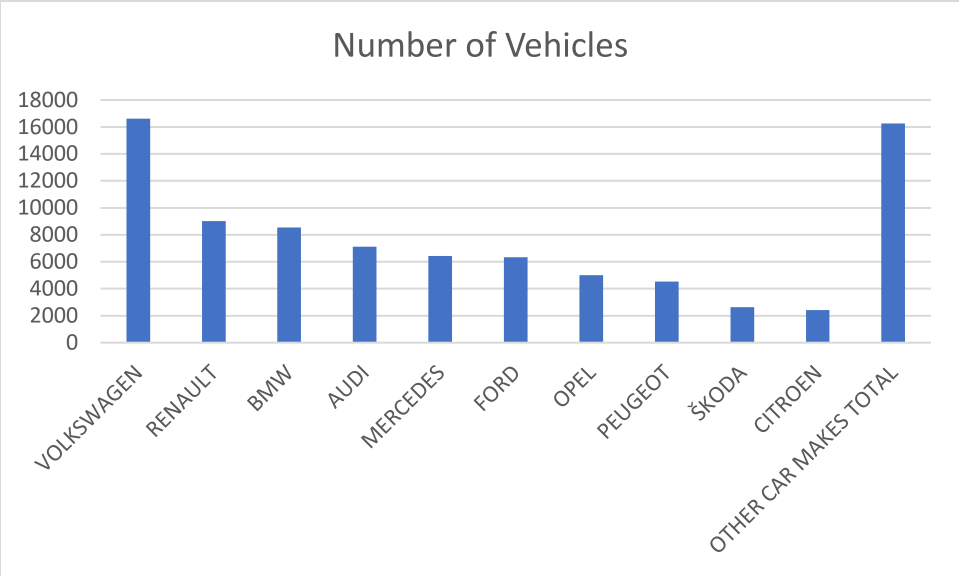

Figure 8: Number of used registered vehicles in 2019 (Source: CVH)

As it can be seen the car makes are lined up starting from the biggest number to the lowest and cumulative rest of the makes at the end. Volkswagen is imported in such quantities that there are actually more of them than all of the other makes that don't make the top ten. There is a couple of new ones here, as was expected, BMW, Audi and Mercedes are very popular makes for import, but due to their high prices, they are not so popular in Croatian retail. Dacia, Fiat, Toyota and Suzuki are apparently not very popular among consumers who decide to import their vehicle.

The next graph (Figure 9) represents the average price for each make is presented.

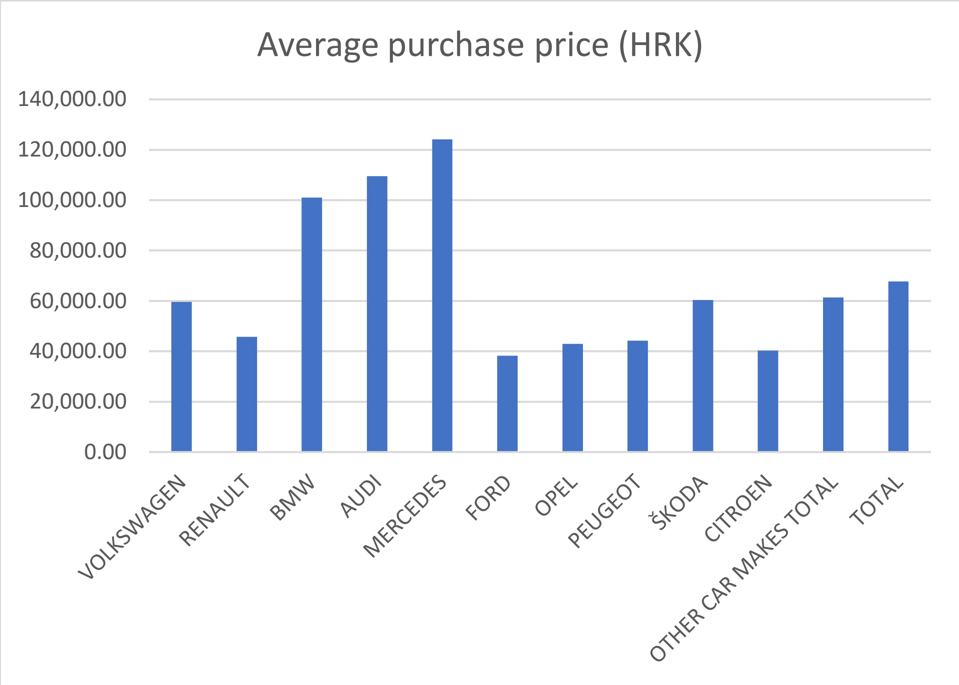

Figure 9: Average price of used vehicles 2019 (Source: CVH)

As expected, Mercedes, BMW and Audi are the three most expensive car makes on the import market, in that exact order. Mercedes is averaging 124,126 kn, which is more than double than Volkswagens 59,570 kn.

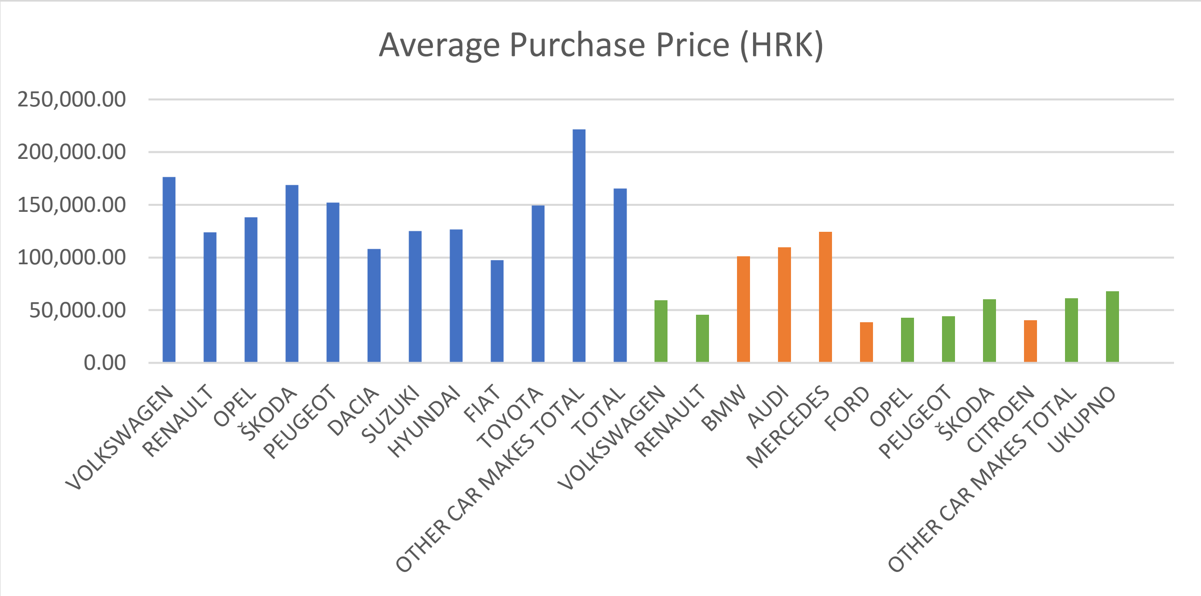

Figure 10: Average price comparison between used and new (Source:CVH)

On this graph (Figure 10) there is a comparison of average prices between new and used. Blue colour shows all the new car makes and their respective prices, green shows the same makes, but used and orange shows used cars that aren't on the list of new cars. It can be observed, that prices of used Mercedes', with the average age of 7 years are more expensive, or same as brand new Renaults, Dacias, Suzukis and Hyundais.

The next chart (Figure 11) represents the average age of used vehicles. Fords are oldest followed by Citroen, Opel, Volkswagen and Mercedes, which is also the most expensive.

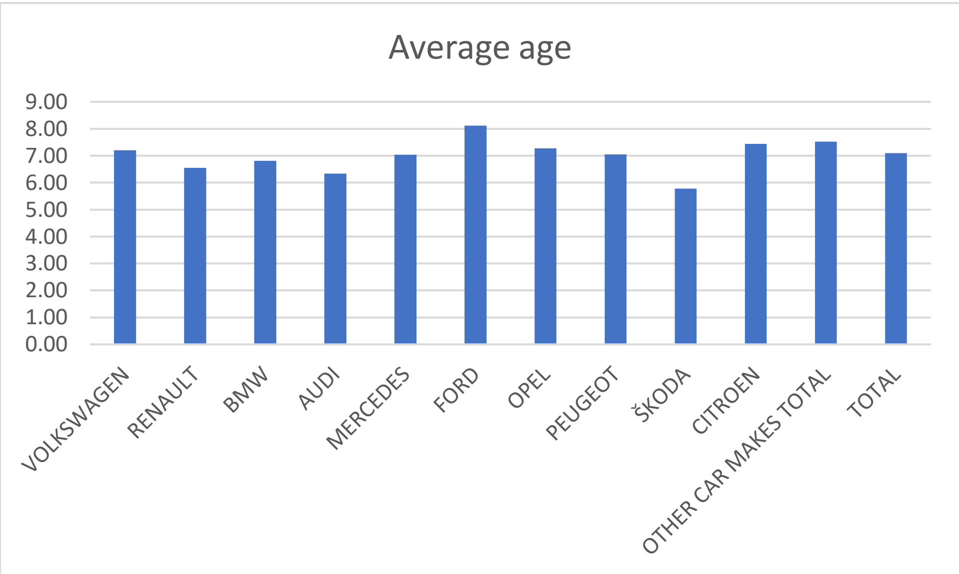

Figure 11: Average age of used vehicles 2019 (Source: CVH)

The next chart (Figure 12) contains the average CO2 emissions per each make. Mercedes, as the most expensive, has the highest CO2 emissions of all the vehicles.

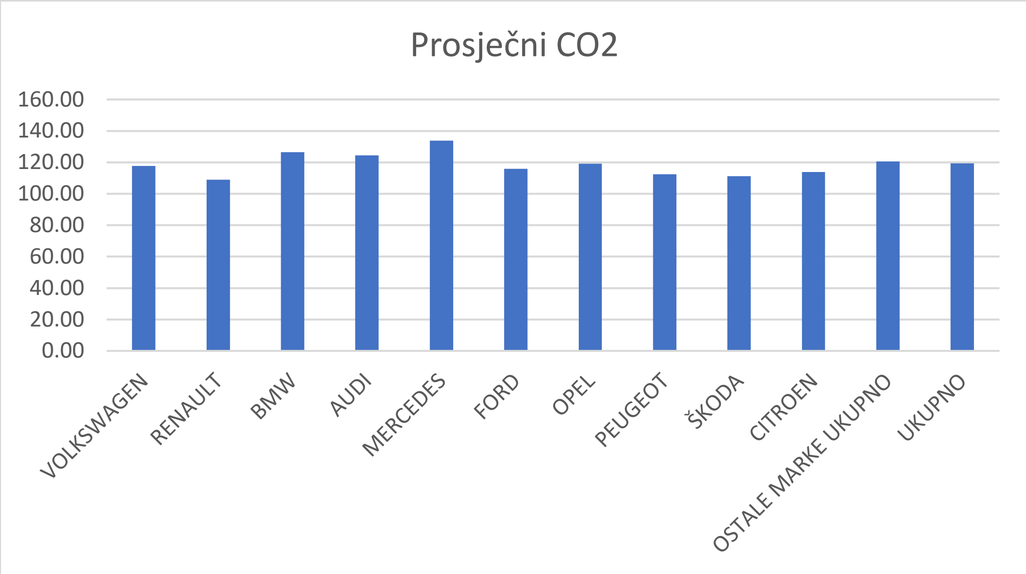

Figure 12: Average CO2 emissions on used cars 2019 (Source: CVH)

2.2.3. Comparison and Discussion

While exploring the European statistics, it was discovered that fiscal income from motor vehicles (from taxes) in 2019 was €440.4 billion. For comparison, here is a table (Table 9) for all registered new and imported vehicles in Croatia for 2019:

New/Used	Number of Vehicles	Average Year of Production	Average Age	Average CO2	Average Purchase Price (HRK)
Used	**84913**	**2011.90**	**7.10**	**119.36**	**67,773.46**
New	**64349**	**2018.87**	**0.13**	**120.51**	**165,323.48**
TOTAL	**149262**	**2014.91**	**4.09**	**119.85**	**109,828.68**

Table 9: All registered vehicles summary 2019 (Source: CVH)

A total of 149,262 vehicles were registered averaging a price of 109,828.68 kn, which is around 16,393,656.63. That is €2,174,909.37. If it is taken into account that average Croatian taxes are around 30%, this makes up for €652,251,272.81 of government fiscal income in 2019. Furthermore, the European Union has 3.72% of electric vehicles, 9.43% hybrid vehicles and 3.05% plug-in hybrid vehicles.[5] In 2019., in Croatia, 730 electric vehicles, 5,547 hybrid and 352 plug-in hybrid vehicles were registered. Electric vehicles make up for 0.49%, hybrids 3.72% and plug-in hybrids 0.24% of all vehicles. That is a total of 4.44%, which means that

[5] Statistics provided by Centar za Vozila Hrvatska (2020)

95.56% of all vehicles on Croatian roads are fuelled by either diesel of petrol.[6] Compared to Norway's 20.29% of petrols and diesels, that is shameful number. That is mostly thanks to the severe lack of government incentive and charging station infrastructure.

[6] CVH https://www.cvh.hr/tehnicki-pregled/statistika/

3. Impact of ICT on Automotive Industry

3.1. Application of ICT in Automotive Industry

According to De Silva, Information and Communication Technology plays a crucial role in creating opportunities for people in every walk of life. The integration if ICT in the automotive industry has added an abundance of new developments. Modern day vehicles have become safer, smarter, more efficient and more connected to the user than ever before.[7]This chapter will explore some aspects of involvement of ICT in the automotive industry, ranging from ICT usage in retail, manufacture to technological developments and safety improvements.

First thing to be talked about in this chapter is the lack of use of ICT in automobile retailers' businesses in Croatia. Effective manipulation of big chunks of data in this day and age is essential to running an effective business. Having workers with the appropriate know how for manipulating big data can considerably increase sales and cut costs in even larger proportions. Proper use of ICT to manipulate big data samples enables companies/platforms such as Netflix, Amazon, YouTube and especially Facebook to tailor what they have in offer to match exactly what each individual consumer wants. They have extremely advanced algorithms which analyze consumer habits and tendencies in order to offer the user a product with the highest likelihood of making an actual transaction. On the other hand, most automobile related web-shops have very poorly designed websites with little effort put into user interface and more importantly user experience. Let's take for an example a configurator on an official website of Volkswagen, as shown in Figure13.

[7] Silva, E., P., M. (2014): Use of ICT in Automobile Industry
https://www.scribd.com/document/198789897/Use-of-ICT-in-Automobile-Industry

The reason for taking Volkswagen for an example is that it is the undisputed number one company for new car sales and used car sales in Croatia, as will be shown in the following chapters.

Figure 13: Golf 8 variants (Source: Volkswagen Hrvatska):

At the time of writing this thesis, if a consumer opens "Volkswagen Hrvatska" website and enters the configurator option, chooses the Golf model as the most sold car model in Croatia for the past 10+ years, they will be offered only two variants of equipment: "Life" and "Style". Upon picking the "Style" variant of equipment, the consumer is offered only two engine options: a 1.5-liter, 150 horsepower petrol and a 2.0-liter 150 horsepower diesel engine, both with a 7-speed dual-clutch automatic transmission. There is only one more option for a 6-speed manual transmission available exclusively with the aforementioned petrol engine.[8] This is an absurdly narrow assortment of available options for their best-selling model.

This example of a lack of variety only goes to show how much room for improvement is possible by applying some form of data mining. "We think the bigger opportunity in the auto space is for folks to start to really look at individual, granular consumer data. Thanks to the

[8] volkswagen.hr https://cc.porscheinformatik.com/cc-hr/hr_HR_VW/V/auv/068?GrossNetSwitch=GROSS&variant=Style

likes of Amazon and Netflix, consumers have become accustomed to "uber-personalized environments they go to a dealer's website and they have a completely static, non-personalized experience." as put by Davin Daly, CEO of a car-dealer company in the US, for an article by David Muller and Hannah Lutz. They proceed to explain that, smarter use of data can show how online shoppers sorted search results pages and that systems can recognize which photos of a vehicle were clicked on, or even that the shopper looked at an SUV with 65000 kilometers and sought certain attributes such as four-wheel drive.[9]

The application of ICT in the automotive industry, apart from improving upon safety and efficiency, has mainly made the largest contribution to the addition of sophisticated functionalities and improving the user experience. Let’s talk for example about navigation. When they were first introduced as a purely navigational tool, all GPS systems could really do was, upon entering the destination and a starting point, map-out a route and provide the driver with simple instructions. After years of development, modern navigation systems can do much more. For example, today, people use navigation to get to destinations they have no trouble finding themselves, even their everyday routes. They do this because these new systems can identify the optimal travel routes based on a variety of factors like traffic density at a given time, user’s preference to paying tolls or needs for gas stations, supermarkets, hotels etc. In some areas they even have fixed police radars and speed bumps mapped in. Modern GPS systems can also keep a record of driving activity, including the address of each destination, names of streets travelled to and how long the vehicle remained at each location which can assist the user in tracking the use of the vehicle, if it’s used as a company pool vehicle.[6]

Although the current state of the industry may be far from vehicle autonomy, which will be explored further in an upcoming chapter, there are some aspects of vehicle autonomy being used right now. There are some high-end, luxurious models of Volvo, Audi, BMW, Tesla, Lexus etc., which can locate and identify an empty parking spot, add throttle, brake and steer into the spot, all on their own. They do this using existing parking sensors and cameras. Some cars like the BMW 7 series and Hyundai Sonata have a special key fob, which enables the user to get out of the car and wait for it to park in, or leave the parking space, without the driver

[9] D. Muller, H. Lutz (June 02, 2019): Data turns dealers into mind readers https://www.autonews.com/shift/data-turns-dealers-mind-readers

even being in the vehicle. Tesla even went one step further and introduced a function which enables the owner to summon his car within the 60-meter radius.[10]

Now let's talk about safety. Safety has become a major factor in automotive industry of late, as the technology advances. There is a vast variety of safety improvements introduced into the modern car that elevate the quality of human life by reducing the risks a driver is exposing himself and others to.[6] Adaptive cruise control, also known as active cruise control and intelligent cruise control, might be regarded as a quality of life improvement, but it is much more of a safety improvement. It is a system designed to enable vehicles to maintain a safe following distance and stay within the speed limit all on its own. ACC works by using sensory technology installed on the vehicle like cameras, lasers and radar equipment, which creates an idea of how close one vehicle is to another, or other objects on the road. This system can maintain constant speed and keep its distance by adding throttle and reducing it, however when there is a sudden change of speed of the vehicle in front the system will issue a warning for the driver to brake hard.[11] Some systems will even brake on their own if there is an object in the way, as long as the moving speed is below 60 km/h.

Each year, a number of accidents on the road happen due to people driving tired and falling asleep. Many car manufacturers have introduced sleep-prevention systems into their cars. These systems can detect if the driver is sleepy based on two different inputs. There are a number of metrics like deviations from lane position, movement of the steering wheel, pressure on the acceleration pedal, which are constantly monitored and if a certain change threshold is reached the systems recognises it as increased probability that the driver is sleepy. Furthermore, the system can monitor the behaviour of the driver such as yawning, eye closure, increase in blinking frequency, head tilt etc. The system will alert the driver if any of those symptoms are noticed. Some studies are also being made on the correlation between physiological signals using electrocardiogram (ECG), electrooculogram (EOG), electroencephalogram (EEG) and electromyogram (EMG) and the driver's sleepiness. [12]

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[10] Brady, D. (2020): Self-Parking Cars Explained: How Does Automatic Park Assist Work? https://www.motortrend.com/news/self-parking-cars-explained/

[11] Car and Driver Research, (2020): What Is Adaptive Cruise Control? https://www.caranddriver.com/research/a32813983/adaptive-cruise-control/

[12] Sahayadhas, A., Sanduraj, K., Murugappan, M. (2012): Detecting Drowsiness Based on Sensors: A Review https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3571819/

There are many more systems that can detect pedestrians or weather conditions like icy roads or fog, tracking of the vehicle in case it gets stolen and so on. It is also important to note that with the development of technology, on-board computer can detect more malfunctions.

3.2. Advantages and Disadvantages of ICT Impact on Automotive Industry

This chapter will explore some major benefits that ICT brought to the modern vehicle and the industry as a whole, as well as some drawbacks that come in hand. There are of course more advantages as technology keeps developing, but with everything good comes a little bit of bad. The application of ICT in automobile manufacturing brings about advantages in several aspects such as general quality of life improvements, safety improvements, efficiency, availability of information and data and reducing the negative effects on the environment. New cars come with an option of a “virtual cockpit”, which basically means that they replace the old analogue instrument cluster with an LCD screen where the owner can arrange what is displayed based on his needs. The owner can choose to display the speedometer and the engine-rev meter with some data on fuel consumption in the middle, or only have the speedometer and a large GPS map covering the rest of the screen. In the last chapter, some safety systems have already been mentioned, such as emergency braking, pedestrian detection, weather monitoring, sleep prevention and so on. Furthermore, the use of new and improved chips and on-board computers allows the manufacturers to enable vehicles to calculate the optimal quantity of fuel gets pumped and at which pressure the turbine pumps the air into the cylinders. These on-board computers can measure exact fuel consumption at any moment, but they are also fitted with algorithms that instruct drivers how to optimally drive in order to obtain more efficiency. There is some general quality of life improvement, like keyless cars with which the owner never even has to take the key out of his pocket or bag. They can lock and unlock the car by just touching the door handle and turn the engine on and off by pressing a button in the car itself. Smart LED headlights which can recognise other vehicles coming ahead and regulate low beam and high beam lighting. They have a grid-like layout of strong LEDs which can individually turn on and off in order to keep maximum visibility for the driver and at the same time not obstruct other driver’s vision.

Many car manufacturers sell little USB like data plugs which can be connected to the on-board computers and to the owner mobile phone, which lets them keep track of important information like the location of the vehicle, tyre change, oil change, crucial information about trips completed. Some people tend to forget where they parked their car, these data plugs can precisely show them where the vehicle is located at any time. It has become very common for vehicles to have parking sensors, cameras and park assist software. Almost all new cars are equipped with the start-stop system which turns of the engine whenever the vehicle comes to a halt and in turn reduces fuel consumption by decent margins.

However, fitting cars with an abundance of electronics comes with some drawbacks as well. Each new model that comes out is equipped with more ICT systems and features, but cars are getting more expensive because of that. The manufacturing costs are increasing, wholesale prices and retail prices will only keep increasing as a consequence. Furthermore, the more systems are equipped and the more complex they get, it opens up for more potential malfunctions and failures. The malfunctions will only get more expensive to fix since the part are getting more expensive themselves. The knowledge required to be a car mechanic for these evolving vehicles will keep increasing, which will lead to more expensive services and maintenance itself. Moreover, the more new, flashy features are available to the driver, the more the driver will be focused on the and distracted from the road. There are of course the aforementioned safety features which should hedge these risks, but they also make drivers more reliant on technology and gradually lower their attention and a careful state of mind. Another issue that can be brought up is the question of security, not just safety. With all the new systems, some of which are connected to the internet, people with malicious intent have an opportunity to hack into the system.

3.3. Future Trends of ICT Usage in the Automotive Industry

3.3.1. Electric Vehicles

This chapter will describe the basics of how electric vehicles work, some key facts about them and explore the advantages and disadvantages of having an electric vehicle.

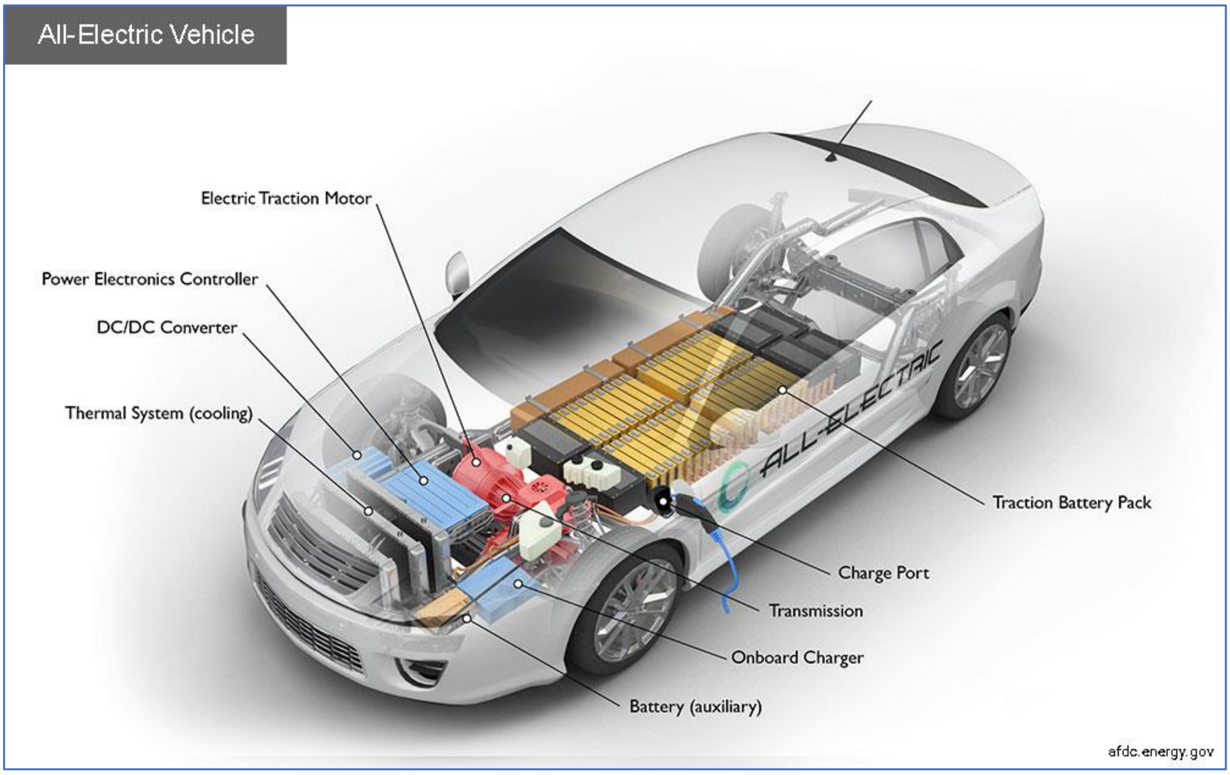

Figure 14: Electric vehicle key components (Source: afdc.energy.gov)

This chapter will focus on all-electric vehicles and not on plug-in hybrids, as they are not what the industry is striving towards. All-electric vehicles, as the name states, have an electric motor instead of the classic internal combustion engine. These cars use a large traction battery pack to power the electric motor and has to be plugged in to a charging station. The main attraction of electric vehicles is that they don't emit any exhaust from a tailpipe. They don't even have a tailpipe as they don't need one. Key components of electric vehicles, as illustrated in Figure 14, are the battery, a charge port, a DC to DC converter, an electric traction motor, an onboard charger, power electronics controller, thermal cooling system, traction battery pack and transmission.

The battery, which is an all-electric auxiliary battery, provides electricity to the vehicle accessories. The traction battery pack stores electricity for powering the electric traction motor. The electric traction motor uses power to drive the vehicle's wheels. The charge port enables the owner to connect to an external power source so they can charge traction battery pack. The DC to DC converter converts higher-voltage DC (direct current) power from the traction battery pack to the lower-voltage DC power needed to run the vehicle accessories and recharge the auxiliar battery. An onboard charger takes the incoming AC (alternating current) electricity supplied through the charge port and converts it to DC power for charging the traction battery. It also monitors battery characteristics like voltage, current, temperature and state of charge. Power electronics controller manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces. Thermal cooling system maintains a proper operating temperature range of the engine, electric motor, power electronics and some other components. Finally, the transmission transfers mechanical power from the electric traction motor to drive the wheels.[13]

Let's take the Tesla Model 3 for an example. Its price tag for the Slovenian market (as it is not yet available in Croatia) starts from around €45,000 and €55,000 for the long-range option. The long-range version can travel at best 409 kilometres. It can get from 0 to 100 km/h in 5.6 seconds and travel at the maximum speed of 225 km/h.[14] In order to recharge the battery, the owner will have to wait for 7 hours and 45 minutes at a Type 2 charge port. If the owner can find a fast-charging point, they can manage it in 22 minutes. Tesla Model 3 comes with rear wheel drive, however there is an option for 4-wheel drive. It has a five-star Euro NCAP safety rating. If the owner has no other choice and has to charge his Tesla Model 3 from a wall plug, it will take them 37 hours for a full charge. Only type of charger that wasn't mentioned is the Type 1 charger, at which the owner will have to wait 12 hours.[15] Most other electric vehicles will only be able to travel anywhere between 250 km to 350 km.

It is important to mention the most notable advantages of electric vehicles. First and foremost, they don't run on gas and therefore the owner doesn't have to pay expensive prices of petrol or diesel. Another very obvious reason is not leaving negative effects on the environment and running on a renewable power source. Electric vehicles are in some aspect less expensive for maintenance and should have failures less frequently. For example, as electric vehicles don't have internal combustion engines with pistons and other moving parts, they do not require

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[13] Energy Efficiency & Renewable Energy, U.S. Department of Energy: How Do All-Electric Cars Work? https://afdc.energy.gov/vehicles/how-do-all-electric-cars-work
[14] Tesla.com https://www.tesla.com/sl_SI/model3/design?redirect=no#battery
[15] Electric Vehicle Database: Tesla Model 3 Long Range Dual Motor https://ev-database.org/car/1138/Tesla-Model-3-Long-Range-Dual-Motor

motor oil. So, owners will save up some money on oil changes. In most countries, Croatia being one of them, there are available tax credits for owner or the buyer can receive subsidy for purchasing one. The Croatian government offers 70,000kn for a fully electric vehicle and 35,000kn for a hybrid vehicle. In most countries public charging spots for electric vehicles offer free electricity. Some countries even have special lanes on motorways and highways for electric vehicles. Furthermore, electric vehicles make almost no noise compared to gas powered vehicles, especially diesels.

Electric vehicles do have their drawbacks. For example, the most notable problem with electric vehicles is the fact that most of them can't travel more than 350 kilometres with one charge. There are some exceptions, like Tesla Model S Long-Range, which can travel for 515 kilometres on one charge at best. That is till significantly less than an entry level Volkswagen Polo. Other cars in the category of a Tesla Model S can travel 1000 kilometres on one tank of gas. Still, to the owner, gas is infinitely more expensive than electricity. Moreover, owners of electric cars will find it troublesome to find charging stations in most parts of Europe. Croatia currently has 117 charging stations across the entire country. 58 of those are Tesla supercharger stations. The following two figures (Figure 15 and Figure 16) present the charging stations located in Croatia. There are 117 charging stations altogether, with 247 connectors. Zagreb has 15 charging stations, none of them are superchargers. Most of them are located around the Zagreb area and along the coastline.

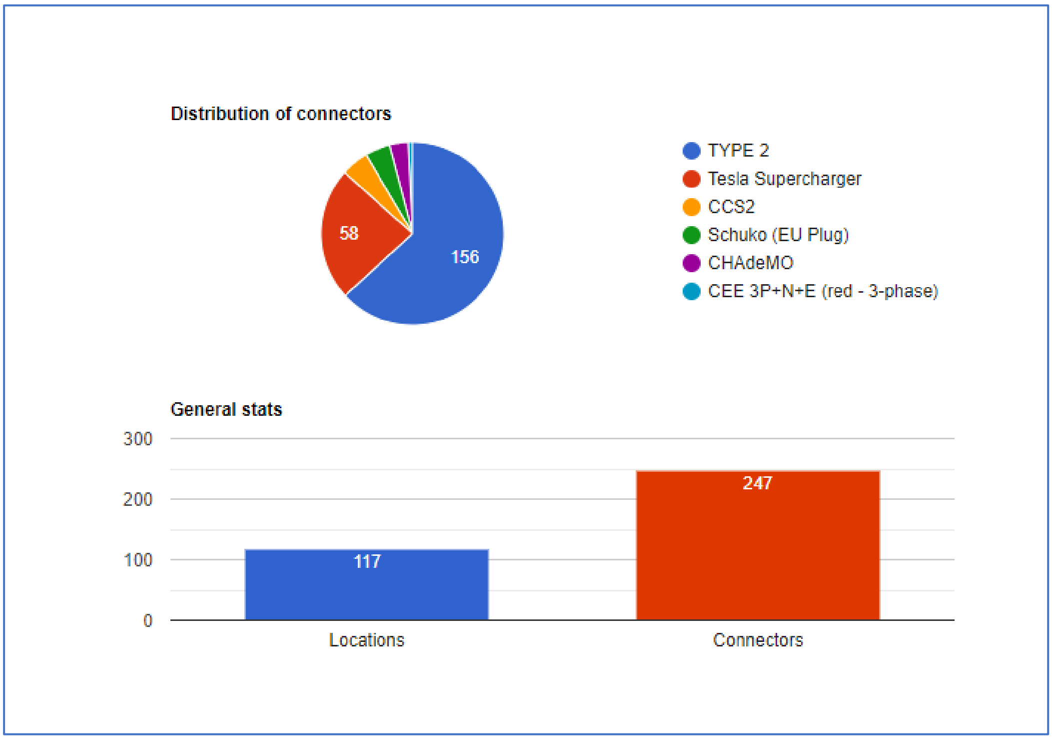

Figure 15: Charging stations for electric vehicles in Croatia (Source: electromaps.com)

Here are the charging stations mapped out. [16]

Figure 16: Map of charging stations for electric vehicles in Croatia (Source: electromaps.com)

Electric vehicles are more expensive to buy in the first place. Let's take for an example the Golf. Basic Golf 8 with a 2.0 litre diesel engine, as shown in a previous chapter will cost around 180,000-200,000kn, while their electric model ID.3 starts at 297,000kn.[7] That's a large price gap. Electric vehicle will likely need a change of battery in their life span, which can turn out to be very expensive.

Let's loosely estimate how long will it take for the owner of an electric vehicle to break even. The price difference between the ID.3 and the Golf is approximately 100,000kn. If the buyer is lucky and is granted the government subsidy of 70,000 kn, that difference then becomes 30,000. Volkswagen claim their new Golf consumes 3,4-4,9 litres of diesel per 100 kilometres. It is well known that those numbers are very hopeful and ambitious. Let's assume that it will consume 6 litres per 100 kilometres in city traffic. An average Croat will travel 15,000 km in one year, thus consuming around 900 litres of diesel. At current prices 1 litre of diesel costs around 9 kn, which means an average car owner will pay around 8,100 kn for fuel each year. It can therefore be estimated that it would take around 4 years for an average driver to break even on gas expenses alone, if the government subsidy is included. Without the subsidy, it would take a little over 12 years.

[16] Electromaps: Charging stations in Croatia https://www.electromaps.com/en/charging-stations/croatia

3.3.2. Autonomous Vehicles

Once, it was a thing of science-fiction to imagine cars driving themselves. Today, it's just a matter of some final touches. This may have been a slight over exaggeration, but the last 5-10 years, technology has made a giant leap towards full vehicle autonomy. All the needed technology is already here, the only remaining challenges are perfecting the artificial intelligence used by these cars, their machine learning capabilities and last but definitely not least, rules, regulations and social acceptability. Firstly, the terminology has to be cleared up. This chapter will focus on full vehicle autonomy, which refers to vehicles that are not only automated, but can make their own rational decisions and correct their own mistakes. According to Scott Totman, the easiest way to distinguish autonomous from automated is by the amount of adapting, learning and decision-making capabilities of the system. Automated systems usually only function within a pre-defined set of rules and routines and have one or a few set tasks. All the manoeuvres, "decisions" and actions an automated system makes are pre-determined by a set of rules and software code.

However, an autonomous system is designed to constantly learn, evolve and adapt to new and dynamic environments full of unknown factors. Autonomous systems, thanks to AI and machine learning, will gain experience just like humans and constantly improve upon decision making within its programmed boundaries and rules.[17]

It is important to have a general understanding of how autonomous vehicles work and what technology they use. They are fitted with cameras, radars, LiDAR sensors, various on-board computers and many other sensors. The hardware fitted on these vehicles has stayed pretty much the same for a number of years; it's actually the software that was mentioned above that is in need of constant change and improvement. Elon Musk actually claimed that cameras are the only piece of hardware needed for achieving vehicle autonomy, once the algorithms can fully comprehend the images received and act upon them. Teslas, for example, have eight external cameras. The next step is to develop an algorithm that can take the feed from the cameras and translate it to a 3D environment. Radar is a radio wave-based sensor which is utilized to measure the distance of other objects. The main advantage of the radar is that it isn't obstructed by weather conditions such as heavy fog, snow, rain etc. LiDAR are sensors with a similar purpose to radar; they emit light and use the feedback to generate a highly-detailed 3D

[17] Matteson, S., Tech Republic (2019.): Autonomous vs automated: What each means and why it matters https://www.techrepublic.com/article/autonomous-versus-automated-what-each-means-and-why-it-matters/

map of its surroundings. Other hardware includes more sensors like GPS, a gyroscope, ultrasonic sensors, inertial sensors and computing power in the form of processors, graphics cards and neural network accelerator chips introduced by Tesla. [18]

The software then comes in and processes the inputs acquired from the previously mentioned hardware, plots a path and sends instructions to the vehicle's actuators, which control acceleration, braking and steering. There are some hard-coded rules like obstacle avoiding algorithms, predictive modelling and smart object discrimination (algorithm used to differentiate bicycles and motorcycles for example), which aim the software to follow traffic rules and navigate obstacles.

Next thing to get into are layers of driving autonomy. There are 6 layers of autonomy and this next part will explain them. Level 1 is also called Driver Assistance, Level 2 – Partial Automation, Level 3 – Conditional Automation, Level 4 – High Automation and Level 5 – Complete Automation. [19]At level 0, all motoric and other major systems are operated by humans. That would, for example, be a plain Fiat Punto from 1999. At level 1, some systems like cruise control, automatic braking are introduced. At level 2, the vehicle can manage at least two simultaneous automated functions, like steering and acceleration. This requires human involvement for safety. An example for this is adaptive cruise control. At level 3, the vehicle can manage all safety-critical functions under some conditions, but it requires the driver to be present to take over control when alerted. Level 4 autonomous vehicles can operate entirely on their own, but in limited scenarios. Level 5 autonomy vehicles are completely capable of driving in any conditions and scenarios.[20]

[18] English, T. (2020.): How Do Self-Driving Cars Work? https://interestingengineering.com/how-do-self-driving-cars-work

[19] Harner, I. (2020): the 5 Autonomous Driving Levels Explained https://www.iotforall.com/5-autonomous-driving-levels-explained/

[20] Union of Concerned Scientists (2017): Self-Driving Cars Explained https://www.ucsusa.org/resources/self-driving-cars-101

The following illustration (Figure 17) provided by SAE International presents the levels of automation.

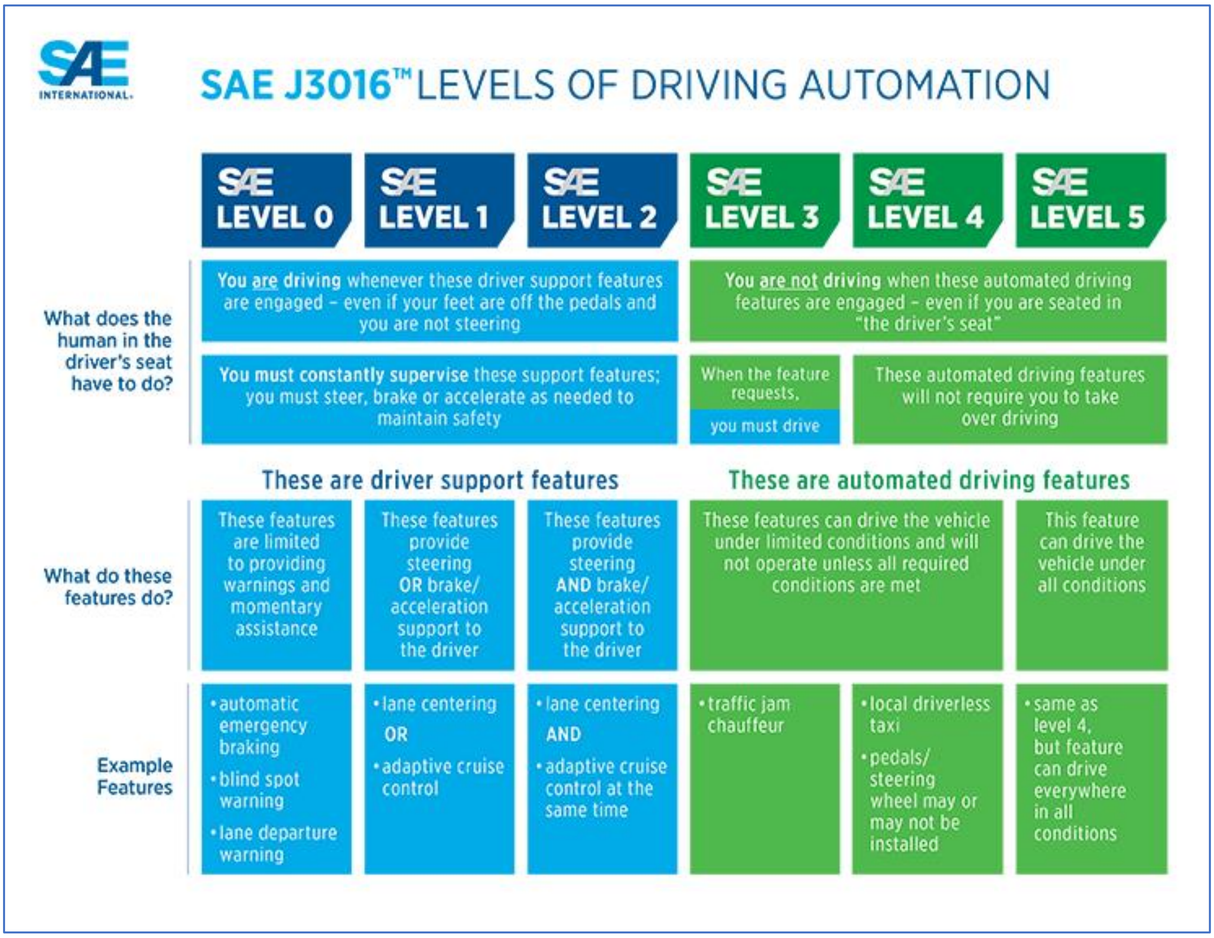

Figure 17: 6 levels of autonomy (Source: SAE)

New regulations are starting to emerge for autonomous vehicles for particular functions, like automated lane assist systems. There is also an international standard for autonomous systems that includes autonomous vehicles, which sets some important requirements but doesn't solve the issue of the basis on which the AI makes its decisions. [21]Defining autonomous driving laws and regulations will definitely be the most challenging obstacle in their final deployment.

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[21] McDermid, J. (2020.): Autonomous cars: five reasons they still aren't on our roads https://theconversation.com/autonomous-cars-five-reasons-they-still-arent-on-our-roads-143316

3.3.3. Application of "Internet of Things" in Automotive Industry

Internet of Things opens up the industry for transformational change. IoT related technologies will mark the path for the future of the automotive industry and interconnected vehicles will play a huge role on the roads and in the economy of the future.[22] It has become apparent that information has become a resource much more valuable than gold or oil.

As explained by Margaret Rouse, the Internet of Things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. A "thing" in the Internet of Things can be a person with a pacemaker, a farm pig with a biochip transponder, a car with built in sensors or any object that can be assigned an IP address. The following figure (Figure 18) is a simplified illustration of how an IoT ecosystem works.[23]

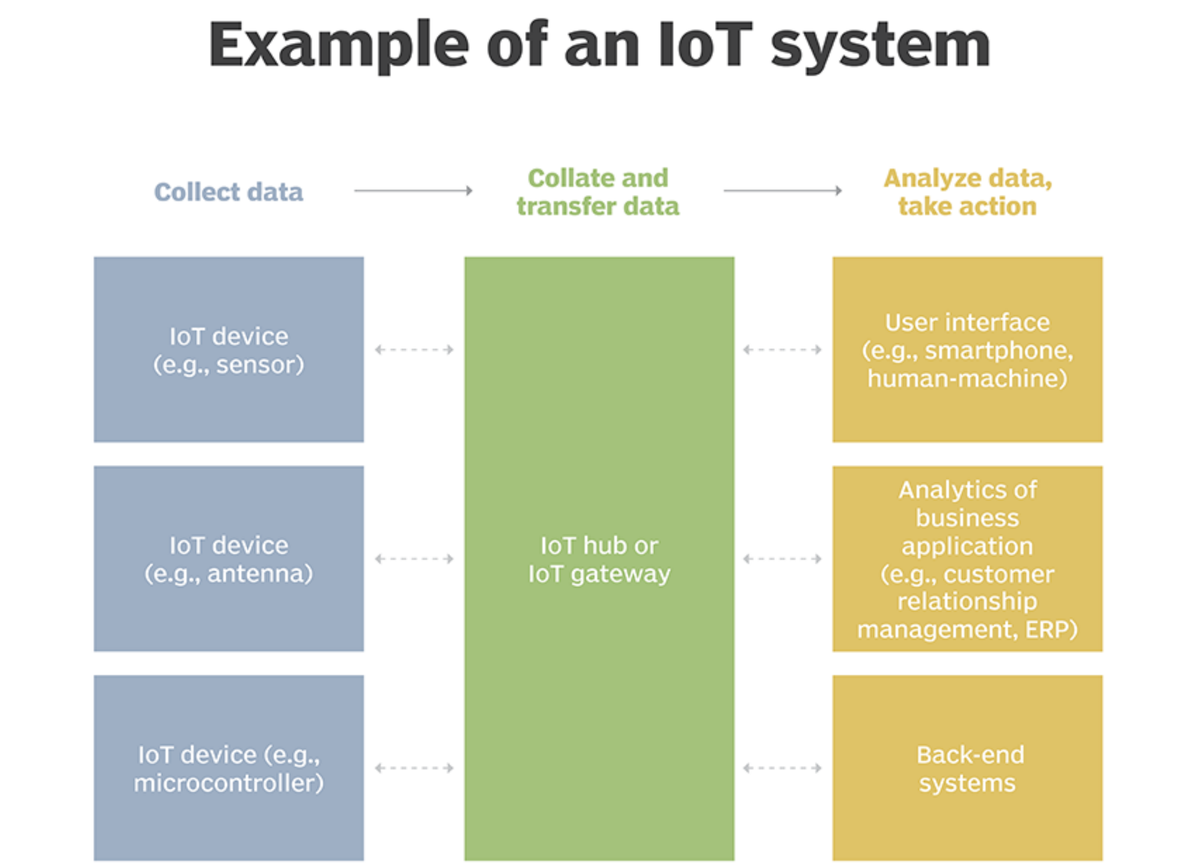

Figure 18: Example of an IoT system (Source:Internet of Things Agenda)

[22] Ninan, S., Gangula, B., von Alten, M., Sniderman, B., Deloitte University Press: Who owns the road? The IoT-connected car of today—and tomorrow

[23] Rouse, M. (2020): internet of things (IoT) https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT

The term IoT is most often used for objects that don't usually have an internet connection, and can communicate with the network without human interaction.[24]

With the application of IoT in the vehicles, there are several major aspects in which it will reshape the industry. If the previous chapter is taken into account, implementing IoT into already autonomous vehicle could mean a great deal in reducing highly congested traffic. The vehicles could communicate to each other and process the data about locations of other units and their planned routes, in order to create their own optimal routes and in turn balancing the traffic on city streets. With a proper analysis of the data gathered by all participants on city streets, conclusions can be made on where the major bottlenecks are, which intersections are problematic. Removing these issues would drastically reduce pollution, energy expenditures and unwanted emissions. Implementing IoT would also lead to better road conditions. This can be achieved with vehicles transmitting information about road maintenance needs to the cloud where it can be mined for data. [25]

[24] Ranger, S. (2020): What is the IoT? Everything you need to know about the Internet of Things right now https://www.zdnet.com/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/

[25] Grayson, P. (2019.): Big Ways IoT is Transforming the Automotive Industry https://futureiot.tech/5-big-ways-iot-is-transforming-the-automotive-industry/

4. Analysis of Research Results regarding ICT Usage in Automotive Industry

4.1. Research Methodology

Research method used in the following part of this thesis is an online survey made through Google Forms. An online survey is among the most used data-collection sources. It is a set of questions sent out via mediums like email, social media, websites, to a target group of respondents. The respondent's answers are saved and the data is available for further analysis. Online surveys are popular because they are very intuitive, mostly free, much more accessible and much simpler than traditional survey. [26]Since the feedback is received in a digital format, data processing is very easy and straightforward. This method is a quantitative research method. The goal of this method is to collect numerical data from the group of respondents in order to gain insight into the state of Croatian automotive industry and respondents' opinions on ICT in modern vehicles.[27] This particular survey is made up of 30 questions divided into 4 sections. The first section is made up of questions regarding the respondent's demographics and personal information. The second section represents general information about the respondent's vehicle. The third section inquires about the respondent's preferences regarding ICT features in vehicles. Finally, the fourth section is about respondent's opinions and viewpoints regarding modern or future ICT systems. Most of the questions are in the multiple-choice format with the purpose of keeping it straightforward; a couple of questions require a short answer. The objective of this survey is to gain insight into respondent's opinions, preferences and standpoints on modern technology in the automotive industry and to learn about key information about their personal vehicle and how it compares to previous investigation of data. The survey was completed by 32 participants.

[26] QuestionPro: Online Surveys: Definition, Characteristics, Examples, Advantages and Disadvantages https://www.questionpro.com/blog/what-are-online-surveys/

[27] Bhatia, M. (2018.): A Complete Guide to Quantitative Research Methods https://humansofdata.atlan.com/2018/06/quantitative-research-methods/

4.2. Research Results

The following table (Table 10) contains the first section of questions and their respective answers.

Age Group	Gender	Type of education	Type of employment	What is your monthly income (HRK)
18-25	M	M.A.	Permanent employment	15,000-20,000
18-25	M	B.A.	Unemployed	0
18-25	M	B.A.	Student contract	3,000-5,999
26-30	M	A.A.	Student contract	0-2,999
41-50	M	M.A.	Permanent employment	15,000-20,000
18-25	M	M.A.	Unemployed	0-2,999
18-25	M	M.A.	Permanent employment	6,000-9999
18-25	F	A.A.	Unemployed	0-2,999
18-25	M	A.A.	Permanent employment	6,000-9999
26-30	M	M.A.	Permanent employment	10,000-14,000
18-25	M	B.A.	Student contract	3,000-5,999
18-25	M	B.A.	Permanent employment	15,000-20,000
26-30	M	M.A.	Permanent employment	10,000-14,000
18-25	F	A.A.	Unemployed	0-2,999
18-25	M	B.A.	Student contract	3,000-5,999
18-25	M	B.A.	Permanent employment	6,000-9999
18-25	F	B.A.	Unemployed	0-2,999
31-40	M	A.A.	Permanent employment	15,000-20,000
18-25	M	B.A.	Permanent employment	6,000-9999
18-25	M	B.A.	Permanent employment	6,000-9999
18-25	M	A.A.	Permanent employment	3,000-5,999
18-25	F	M.A.	Temporary contract	6,000-9999

26-30	F	M.A.	Student contract	0-2,999
18-25	F	M.A.	Unemployed	0-2,999
18-25	F	B.A.	Unemployed	0-2,999
26-30	F	M.A.	Permanent employment	6,000-9999
31-40	M	A.A.	Unemployed	6,000-9999
26-30	F	B.A.	Permanent employment	15,000-20,000
26-30	F	M.A.	Permanent employment	6,000-9999
26-30	F	M.A.	Temporary contract	6,000-9999
26-30	M	M.A.	Temporary contract	6,000-9999
18-25	Ž	B.A.	Student contract	3,000-5,999
26-30	M	M.A.	Permanent employment	10,000-14,000
18-25	M	B.A.	Temporary contract	6,000-9999

Table 10: Demographics section (Source: Author's research)

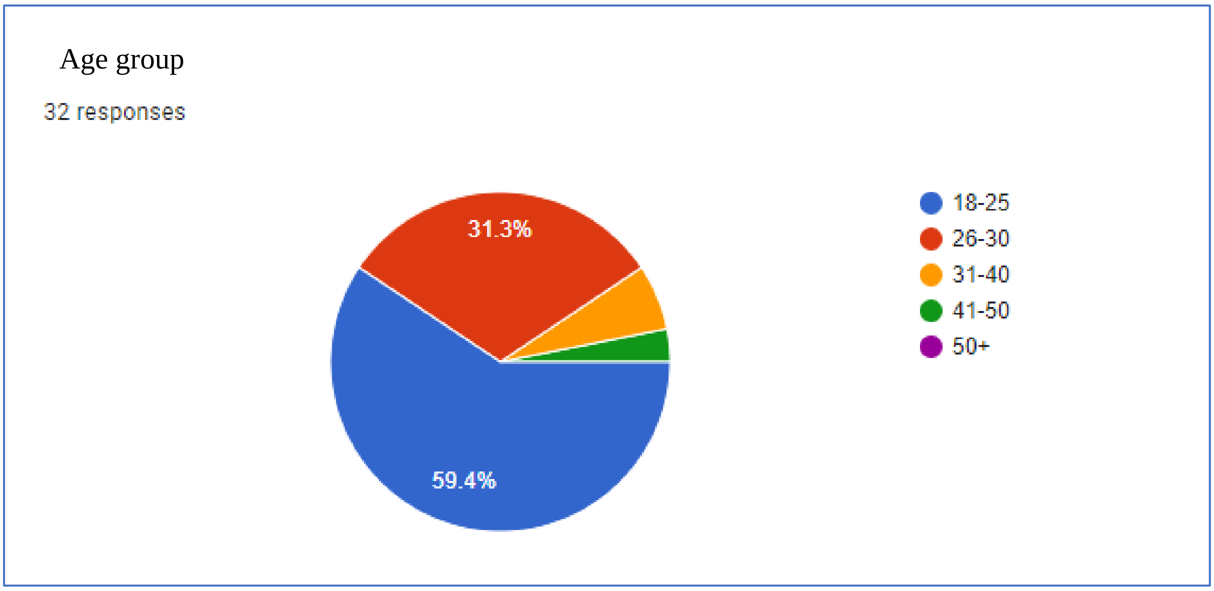

Figure 19: Age groups of participants (Source: Author's research)

In the first question it can be observed that the majority of participants – 59.4%, are between 18 and 25 years old. This is expected as this survey was distributed mostly to friends and colleagues. Out of the 32 participants, 31.3% of them are 26-30 years old. (Figure 19)

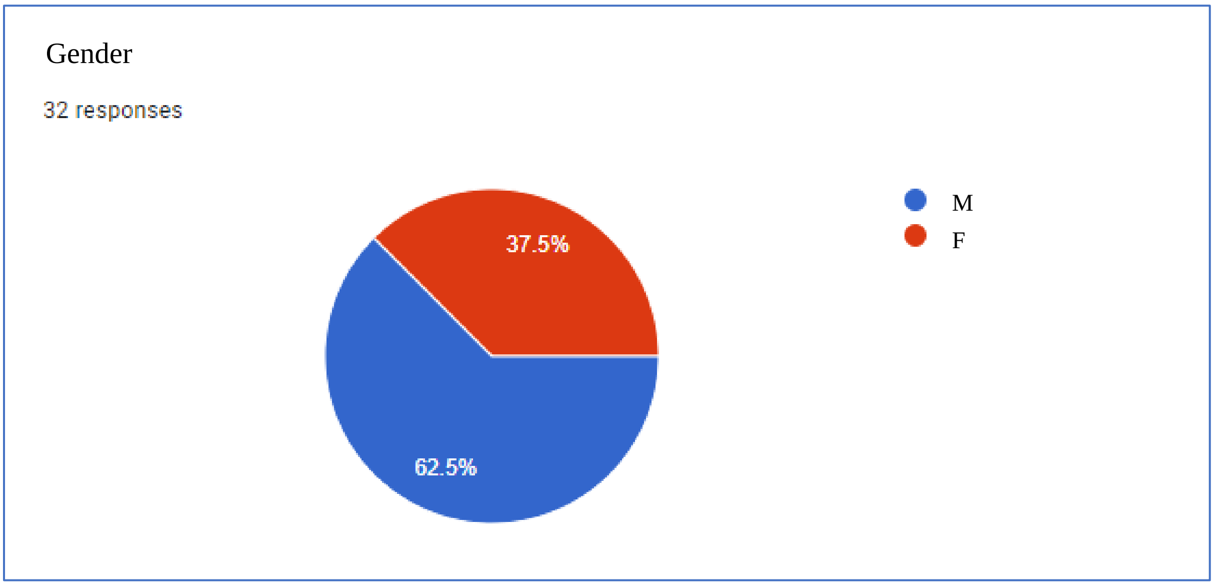

Figure 20: Gender of participants (Source: Author's research)

Out of 32 participants, 20 of them are male and 12 are female. (Figure 20)

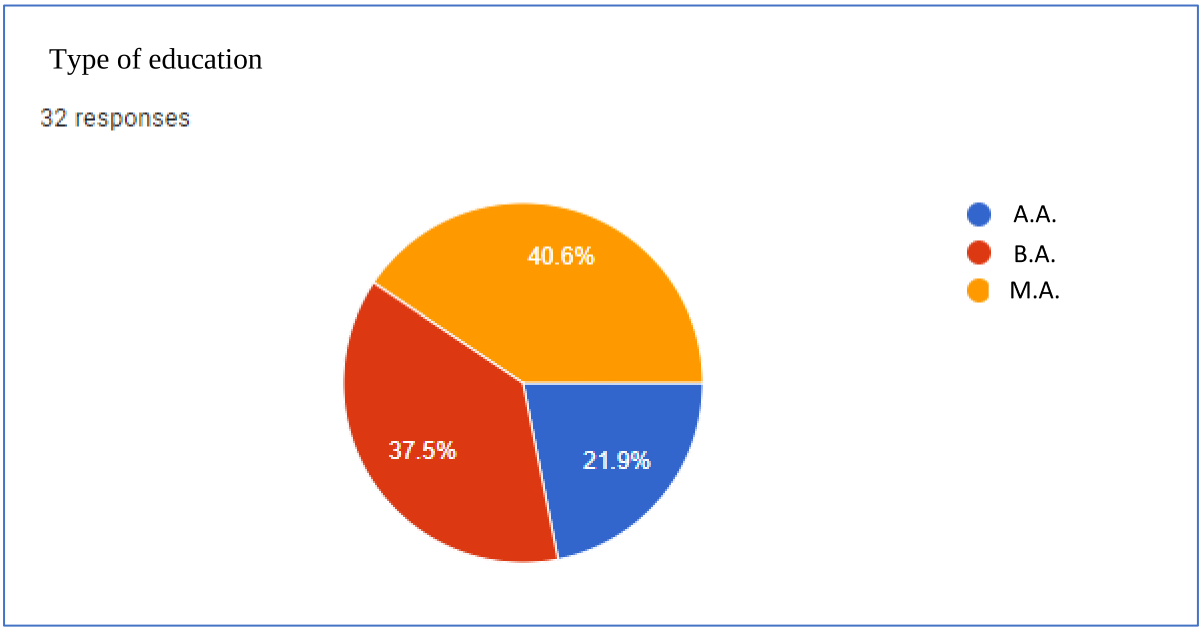

Figure 21: Education of participants (Source: Author's research)

Thirteen participants have a master's degree, twelve have a bachelor's degree and the remaining seven currently are high school graduates. (Figure 21)

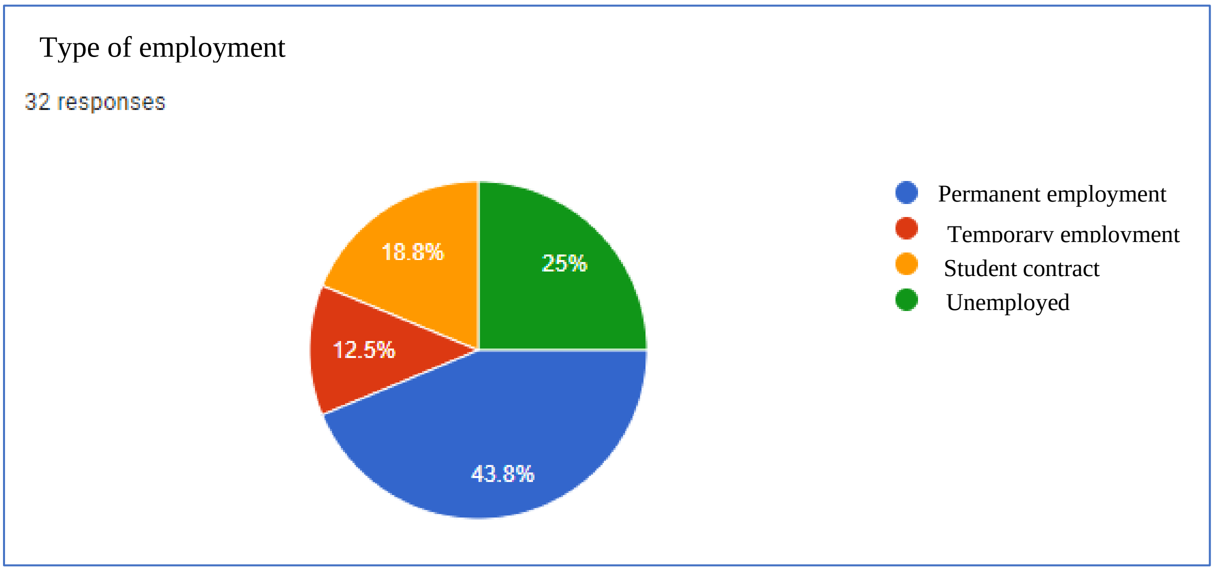

Figure 22: Employment type of participants (Source: Author's research)

14 participants are permanently employed, 4 are on a limited contract, 6 of them work as students and 8 are currently unemployed. (Figure 22)

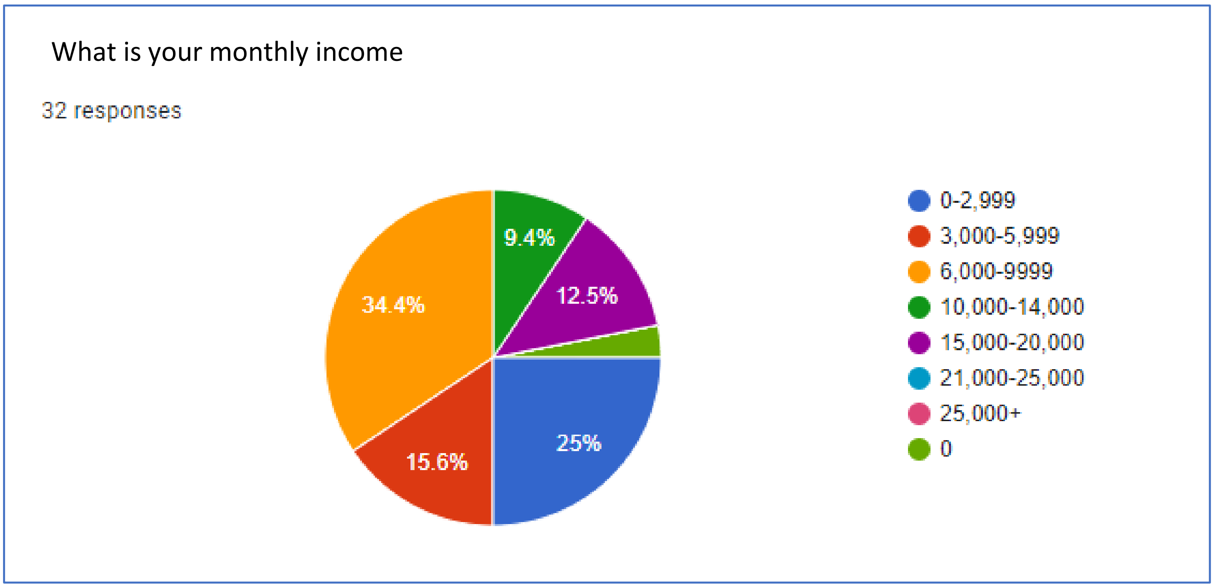

Figure 19: Monthly incomes of participants (Source: Author's research)

This chart (Figure 23) shows us the approximate monthly net incomes of participants. This data is important for comparison with the average price of a vehicle in Croatia, and more importantly with the prices of vehicles of survey participants. 34.4% have a monthly net income of 6,000-7000kn, which matches the national average monthly net income. 25% of participants make less than 3,000kn, which matches the number of participants working on a student contract. 9.4% make 10,000-14,000kn, 12.5% make 15,000-20,000kn and one participant doesn't have any income.

The following table (Table 11) shows the second section of questions with their answers, regarding the general information about participants' vehicles.

Car brand	Car model	Year of production	Was the car purchased used or new?	Which owner are you?	What was the purchase price of the car (HRK)	What is the total mileage? (km)	What are the CO2 emissions? (g/km)	Which type of fuel is used?	Which type of transimssion is used?
K	J	2000	New	First	200,000-400,000	200,000-300,000	70-79	Diesel	Manual
Audi	A4	2002	New	Second	150,000-200,000	200,000-300,000	120-149	Diesel	Manual
Fiat	Punto	1997	Used	Third	30,000-70,000	150,000-200,000	100-119	Petrol	Manual
Mercedes	GLA	2015	New	First	200,000-400,000	100,000-150,000	90-99	Diesel	Automatic
Škoda	Superb	2020	New	First	200,000-400,000	0-20,000	90-99	Diesel	DSG (Dual clutch automatic)
Suzuki	sx4	2006	New	Second	30,000-70,000	60,000-80,000	70-79	Petrol	Manual
Volkswagen	Polo 1.4	2001	New	Second	100,000-150,000	100,000-150,000	150-179	Petrol	Manual
Volkswagen	Polo	2018	Used	Second	70,000-100,000	0-20,000	80-89	Diesel	Manual
Mazda	3	2011	Used	Third	30,000-70,000	100,000-150,000	100-119	Diesel	Manual
VW	Polo	2015	Used	Second	30,000-70,000	40,000-60,000	70-79	Diesel	Manual
Renault	Megan	2007	Used	Third	30,000-70,000	200,000-300,000	90-99	Diesel	Manual
Renault	Thalia	2002	New	Second	30,000-70,000	150,000-200,000	100-119	Petrol	Manual
Volkswagen	Golf	2015	Used	Second	100,000-150,000	40,000-60,000	0-39	Hybrid	DSG (Dual clutch automatic)
Nissan Juke	Juke, 1.0 DCT TEKNA	2020	New	Second	200,000-400,000	0-20,000	100-119	Petrol	Automatic
Audi	A3	2016	Used	Second	100,000-150,000	60,000-80,000	90-99	Diesel	DSG (Dual clutch automatic)
Golf	7	2015	New	First	100,000-150,000	60,000-80,000	80-89	Diesel	Manual
Mercedes	A klasa	1999	Used	Second	70,000-100,000	80,000-100,000	40-69	Petrol	Manual
opel	astra	2009	Used	Third	30,000-70,000	200,000-300,000	70-79	Petrol	Manual
Peugeot	308	2019	New	First	100,000-150,000	0-20,000	70-79	Diesel	Manual
Volkswagen	Golf	2015	New	First	100,000-150,000	60,000-80,000	80-89	Diesel	Manual
Renault	Clio	2016	Used	Second	70,000-100,000	60,000-80,000	80-89	Petrol	Manual

VW	Tcross	2020	New	First	150,000-200,000	0-20,000	100-119	Petrol	DSG (Dual clutch automatic)
Hyundai	atos	2000	Used	Second	30,000-70,000	40,000-60,000	0-39	Petrol	Manual
Audi	A3 Sportback	2017	Used	Second	100,000-150,000	80,000-100,000	100-119	Diesel	Automatic
Mercedes	A klasa	1999	Used	Second	70,000-100,000	80,000-100,000	40-69	Petrol	Manual
Opel	Corsa	2003	Used	Third	30,000-70,000	100,000-150,000	120-149	Petrol	Manual
opel	corsa	2003	Used	Third	30,000-70,000	100,000-150,000	120-149	Petrol	Manual
Vw	Up!	2017	Used	Second	30,000-70,000	20,000-40,000	90-99	Petrol	Manual
Škoda	Octavia	2018	New	First	150,000-200,000	20,000-40,000	80-89	Diesel	Manual
Renault	Clio	2015	Used	Second	30,000-70,000	40,000-60,000	90-99	Petrol	Manual
Toyota	Yaris	2016	New	First	150,000-200,000	40,000-60,000	80-89	Hybrid	Manual
Volkswagen	Passat	2016	Used	Second	100,000-150,000	80,000-100,000	90-99	Diesel	DSG (Dual clutch automatic)
Renault	Talisman	2016	New	First	200,000-400,000	80,000-100,000	90-99	Diesel	DSG (Dual clutch automatic)
Renault	Megane	2006	Used	Second	30,000-70,000	100,000-150,000	100-119	Diesel	Manual

Table 11: Key vehicle data questions (Source: Author's research)

Figure 24 illustrates the participants' vehicles by their brand.

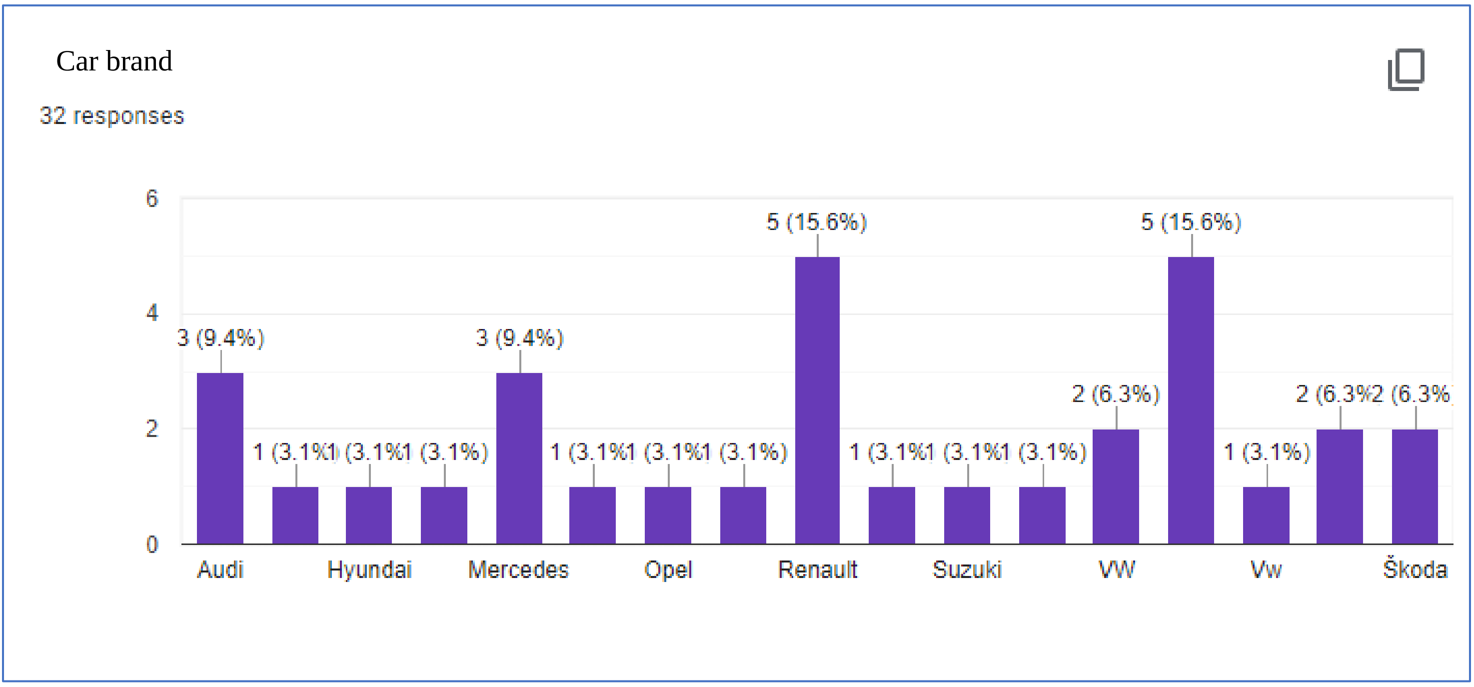

Figure 20: Car make (Source: Author's research)

As expected, Volkswagen takes first place for the highest number of vehicles – 8. Following that, Renault with 7, Mercedes,Audi and Opel with 3. There are two Škodas and one of each following: Fiat, Hyundai, Mazda, Nissan, Peugeot, Suzuki and Toyota. Comparing these numbers to data from chapter 2.3.2. it can be concluded that they are closely related. In both new and used cars tables Volkswagen and Renault were the first two, in that order, followed by Opel and Škoda. This is actually, exactly the same order as in the official data provided by CVH. The following chart represents the respective models for these vehicles.

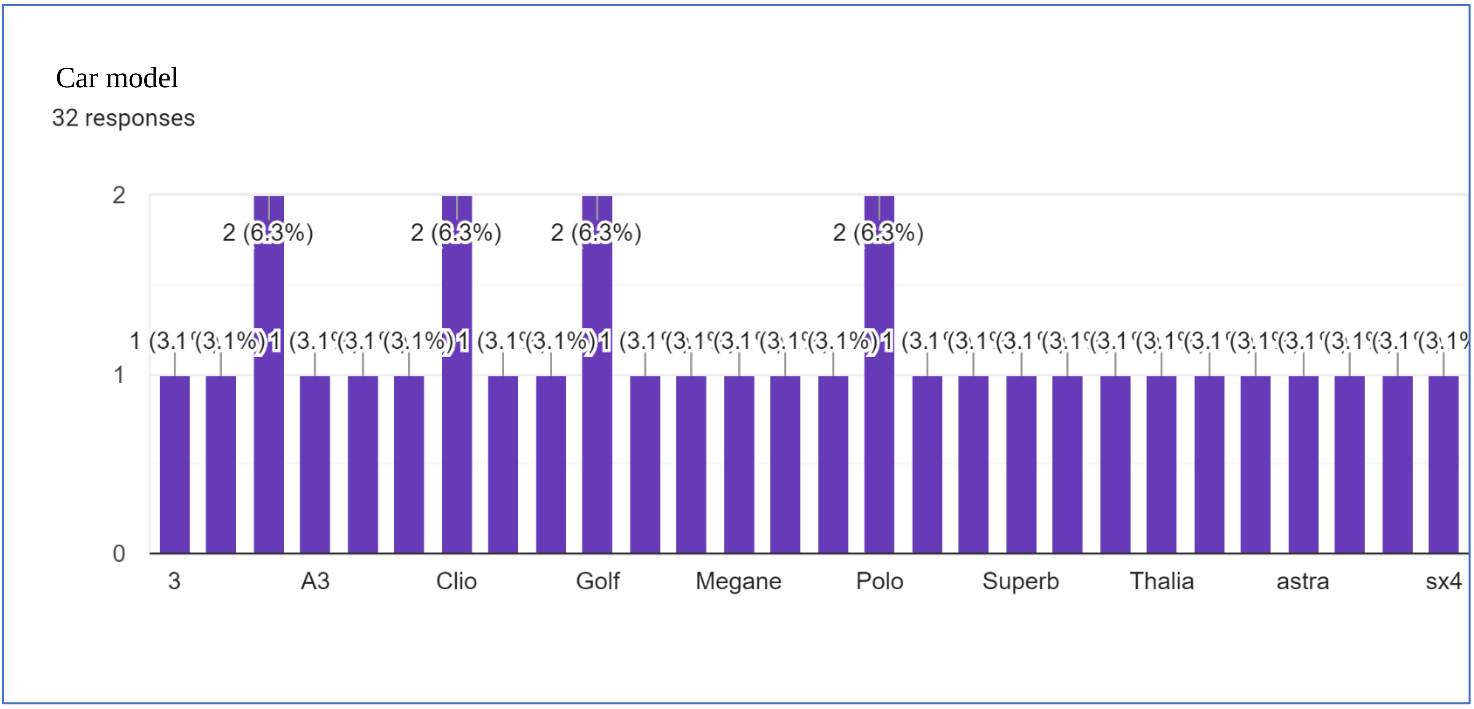

Figure 21: Car model (Source: Author's research)

There are two of each of the following models: Volkswagen Golf, Audi A3, Mercedes A class, Renault Clio and Megane and Opel Corsa. There are also three Volkswagen Polos. This result is very expected, since the most popular car category is a hatchback, and all of these models, without exception, are hatchbacks. (Figure 25)

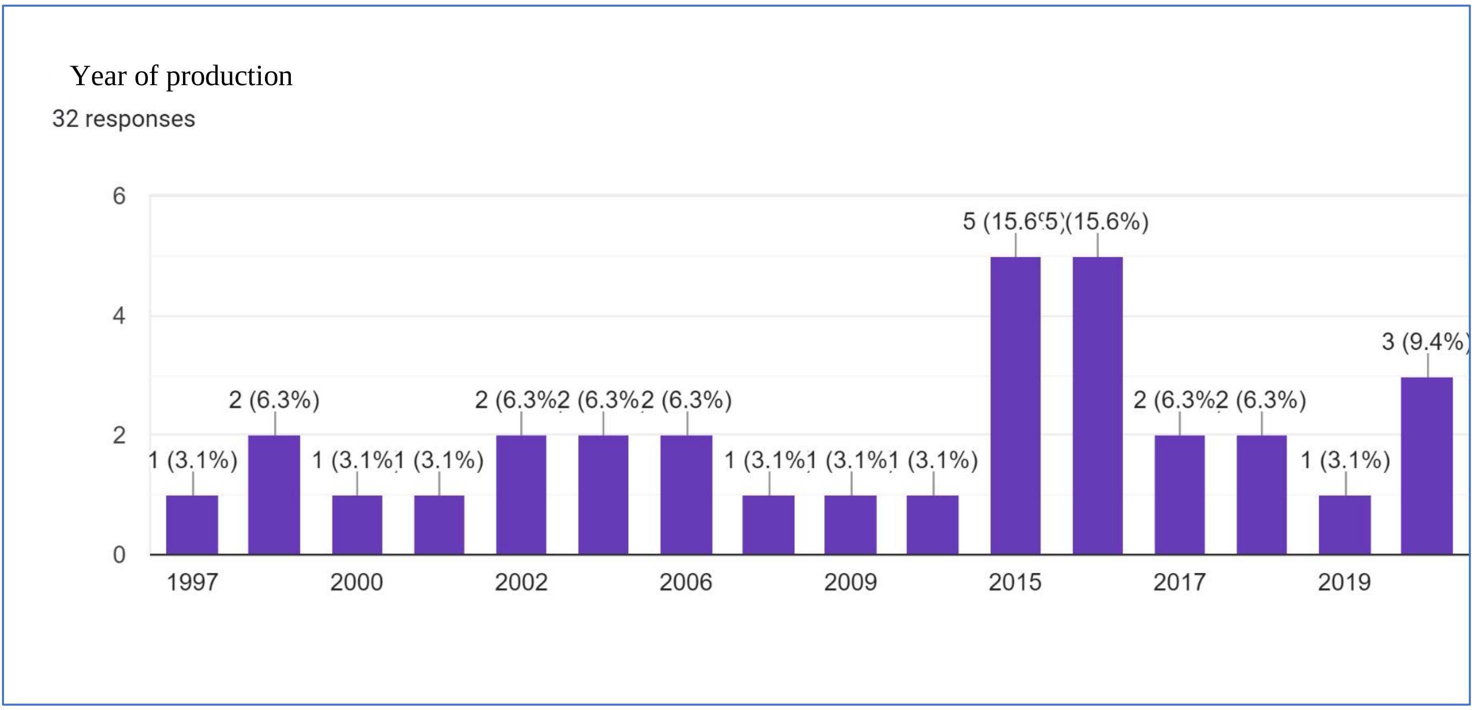

Figure 22: Year of production (Source: Author's research)

This chart (Figure 26) reveals the manufacture year for each participants' vehicle. Five vehicles are 5 years old and 5 are 4 years old. In chapter 2.3.3., it was discovered that the average age of all registered vehicles in 2019. Is 4.09 years, so the data from the survey matches the data acquired from CVH. However, the data from CVH only includes registrations for new vehicles and imported vehicles, it doesn't contain the second, third, fourth etc. registration of the same vehicle. The real average age of vehicles on Croatian roads is older than 4. If the age of each participants' vehicle is considered and the mean is calculated, the result is the average age of 9.92 years. According to Poslovni.hr, the average age for Croatian vehicles in 2018. was 12,6 years.[28] The average age of vehicles in the European Union is 10,8 years.[29]

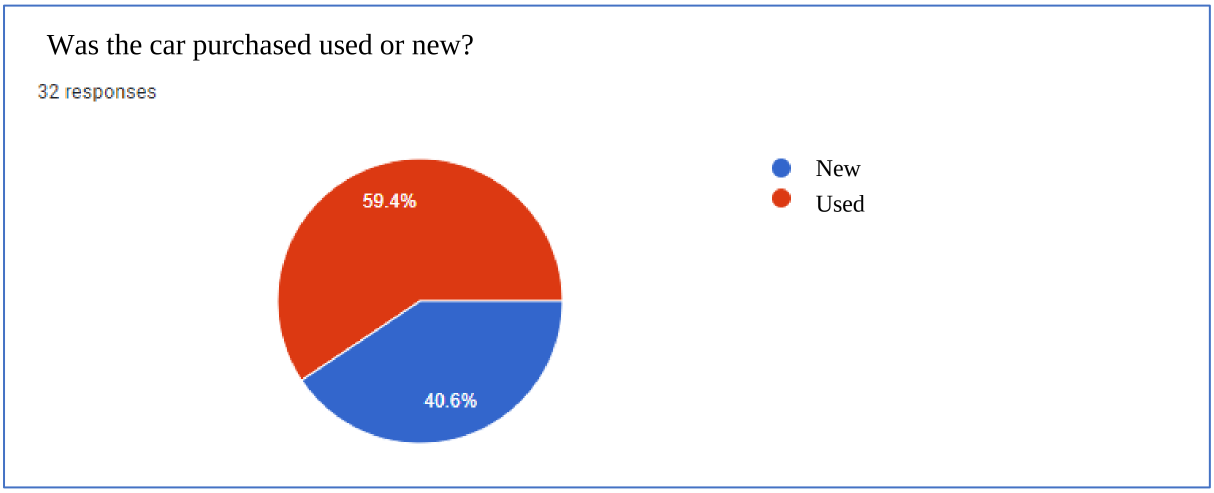

Figure 23: New or used vehicle (Source: Author's research)

Here, the participants were asked if they purchased their vehicle new or used. Almost 60% of the bought a used vehicle. (Figure 27) The following figure shows the approximate price the participants payed for their vehicles.

[28] Poslovni dnevnik/Hina (2019.): Otkrivena prosječna starost vozila u Hrvatskoj: Jedna stvar je posebno zabrinjavajuća https://www.poslovni.hr/hrvatska/otkrivena-prosjecna-starost-vozila-u-hrvatskoj-jedna-stvar-je-posebno-zabrinjavajuca-358349

[29] ACAE.be(2020.): Average age of the EU fleet https://www.acea.be/statistics/tag/category/average-vehicle-age

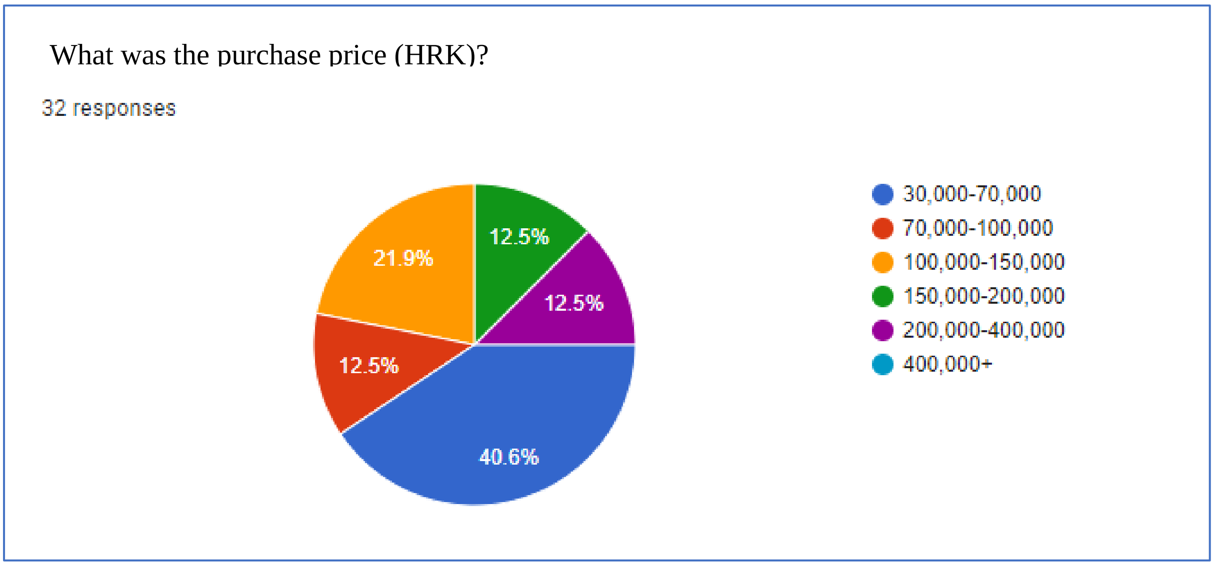

Figure 28: Purchase price of vehicle (Source: Author's research)

The majority of respondents payed between 30,000kn and 70,000kn for their cars. The second biggest bracket of car value belongs to 21.9% participants. Three groups of 4 participants, or 12.5% payed 70,000-100,000kn, 150,000-200,000kn and 200,000-400,000kn. Nobody payed of 400,000kn for a vehicle. (Figure 28)

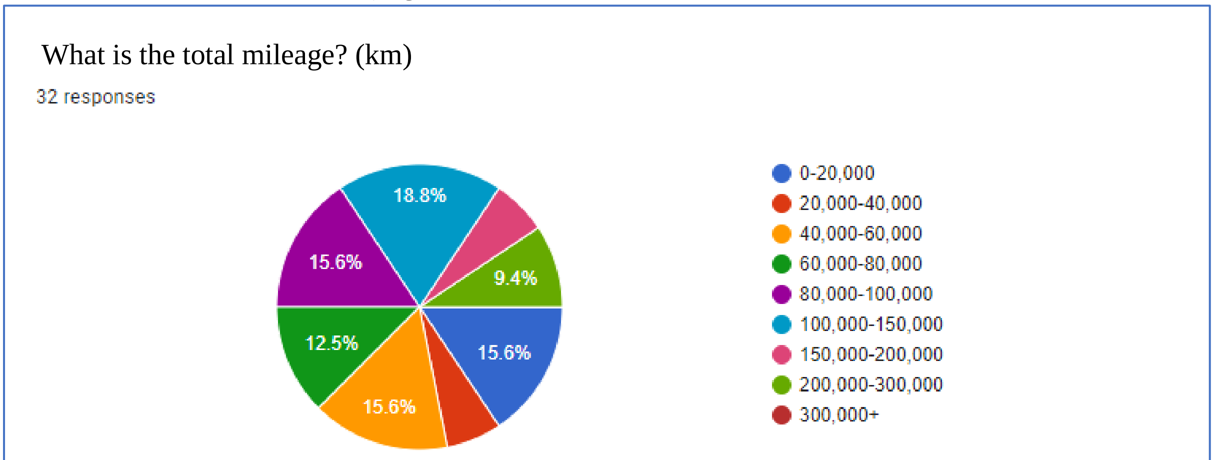

Figure 29: Total no. of kilometres (Source: Author's research)

This chart (Figure 29) shows us the approximate total number of kilometres each of the participants' cars has made. Most cars have made 100,000-150,000 kilometres. However, the distribution is pretty even across the range.

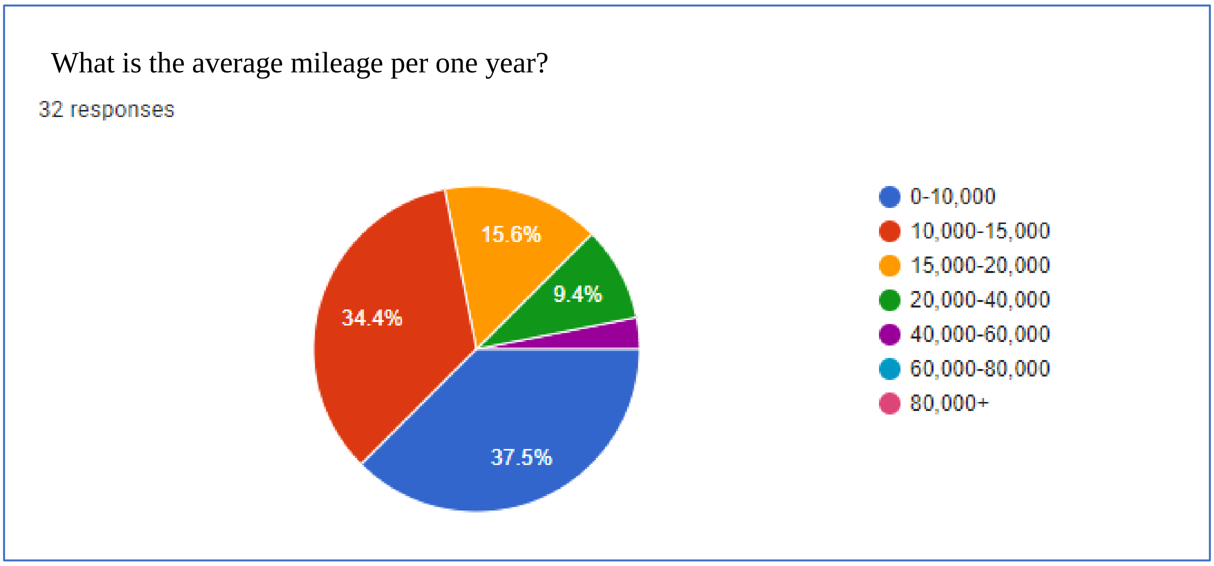

Figure 30: Average no. of kilometres per year (Source: Author's research)

This question, illustrated in Figure 30, is about the average number of kilometres each of the participants' vehicles makes per year. As expected, the majority of vehicles make under 10,000 kilometres, and a similar share of participants' travel between 10,000 and 15,000 kilometres per year. The Croatian average is around 10,000-15,000 km.

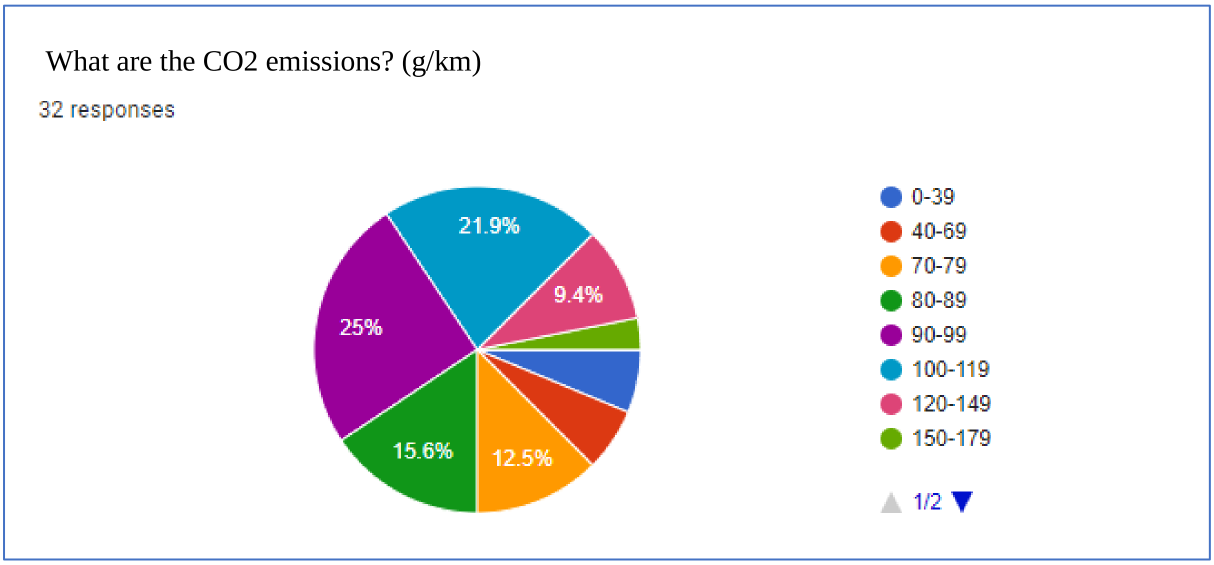

Figure 31: CO2 emissions (Source: Author's research)

In this question, shown in Figure 31, the respondents were to reveal the CO_2 emissions of their vehicles. 25% of vehicles emit between 90 and 99 grams of CO_2 per kilometre. 21.9% of them emit between 100 and 119 grams of CO_2 per kilometre. The other two significant chunks represent the 80-79 and 80-89 g/km range. This result, however, should be taken with a grain of salt, because vehicles older than 10-12 years don't have their CO_2 emission stated in the registration. The reason for this is that only recently the laws were introduced for manufacturers to measure the emissions of their vehicles, and Croatian technical inspection stations don't have the devices and machinery used for the measurements.

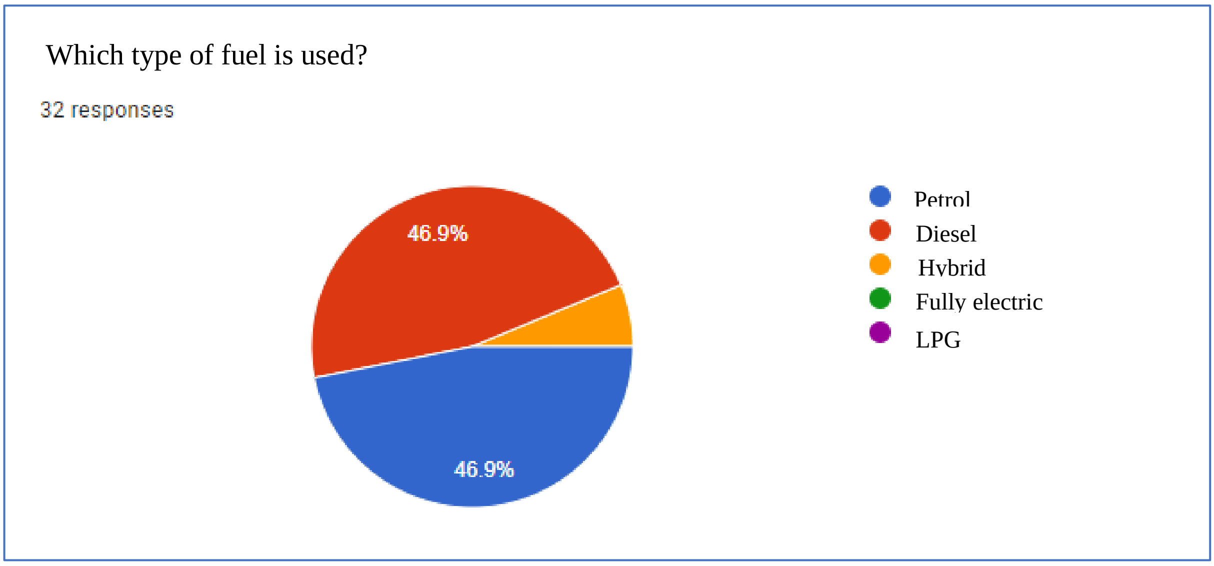

Figure 24: Type of fuel (Source: Author's research)

This chart (Figure 32) shows us the fuel type used in the participants' vehicles. This basically confirms the data received from CVH, or rather vice versa. 93.8% of all vehicles in the survey are either diesel or petrol engines. To be exact, there is the same amount of diesel and petrol vehicles – 15 for each side. The remaining two are hybrid vehicles. One Volkswagen Golf GTE and one Toyota Yaris hybrid. Hopefully this will change in the upcoming years.

This final question of section 2, shown in Figure 33, reveals the type of transmission of each vehicle in the survey. Vast majority of them (71.9%) use the plain manual transmission. 3 vehicles have the basic, single clutch, automatic transmission. 6 vehicles use the latest technology, the dual clutch automatic transmission.

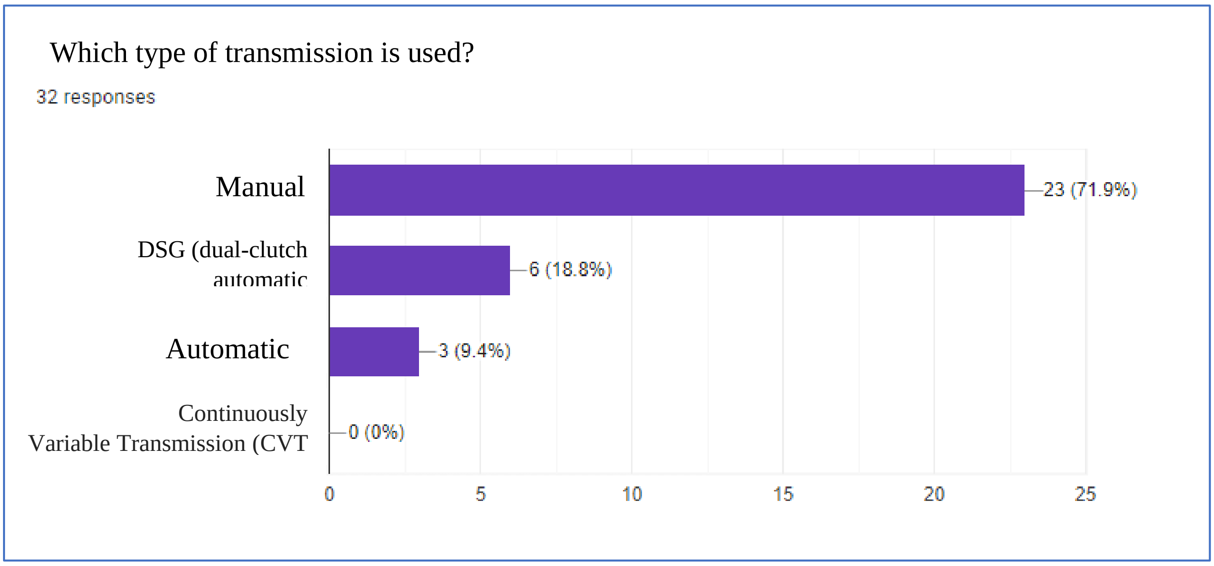

Figure 25: Type of transmission (Source: Author's research)

The following table (Table 12) represents all the answers to questions in the third section, regarding the participants' preferences for technology in cars.

Can your vehicle establish a connection with your smartphone?	What would you prefer when buying a car?	What would you prefer when buying a car?	What would you prefer when buying a car?	What would you prefer when buying a car?	What would you prefer when buying a car?	What would you prefer when buying a car?
No	Smartphone connection ability	More horsepower	Virtual cockpit	Front-wheel drive	More horsepower	Self-park
No	More horsepower	More horsepower	Virtual cockpit	Rear-wheel drive	All-wheel drive	Self-park
No	More horsepower	More horsepower	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
Yes	More horsepower	More horsepower	More horsepower	Front-wheel drive	All-wheel drive	Self-park
Yes	More horsepower	More horsepower	Virtual cockpit	Front-wheel drive	All-wheel drive	Start-stop system
No	Smartphone connection ability	GPS	Virtual cockpit	Rear-wheel drive	More horsepower	Self-park
No	More horsepower	More horsepower	More horsepower	Front-wheel drive	More horsepower	Start-stop system
Yes	More horsepower	GPS	Virtual cockpit	Rear-wheel drive	More horsepower	Self-park
No	More horsepower	More horsepower	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
No	More horsepower	More horsepower	Virtual cockpit	Front-wheel drive	More horsepower	Start-stop system
No	More horsepower	More horsepower	More horsepower	Front-wheel drive	All-wheel drive	Start-stop system
No	More horsepower	More horsepower	More horsepower	Rear-wheel drive	More horsepower	Self-park

Yes	More horsepower	More horsepower	More horsepower	Rear-wheel drive	More horsepower	Self-park
Yes	More horsepower	More horsepower	Virtual cockpit	Rear-wheel drive	All-wheel drive	Self-park
Yes	Smartphone connection ability	More horsepower	Virtual cockpit	Rear-wheel drive	All-wheel drive	Self-park
Yes	Smartphone connection ability	More horsepower	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
No	Smartphone connection ability	GPS	Virtual cockpit	Rear-wheel drive	All-wheel drive	Self-park
No	More horsepower	More horsepower	More horsepower	Front-wheel drive	All-wheel drive	Self-park
Yes	More horsepower	More horsepower	More horsepower	Front-wheel drive	All-wheel drive	Self-park
Yes	Smartphone connection ability	GPS	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
Yes	More horsepower	More horsepower	More horsepower	Rear-wheel drive	More horsepower	Start-stop system
Yes	Smartphone connection ability	More horsepower	Virtual cockpit	Rear-wheel drive	All-wheel drive	Self-park
No	More horsepower	More horsepower	More horsepower	Rear-wheel drive	All-wheel drive	Start-stop system
Yes	More horsepower	More horsepower	Virtual cockpit	Rear-wheel drive	More horsepower	Start-stop system
No	Smartphone connection ability	GPS	Virtual cockpit	Rear-wheel drive	All-wheel drive	Self-park
No	More horsepower	More horsepower	More horsepower	Front-wheel drive	All-wheel drive	Self-park
No	More horsepower	More horsepower	More horsepower	Front-wheel drive	More horsepower	Start-stop system
Yes	Smartphone connection ability	More horsepower	More horsepower	Front-wheel drive	All-wheel drive	Self-park
Yes	Smartphone connection ability	GPS	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
Yes	More horsepower	GPS	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
Yes	Smartphone connection ability	GPS	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
Yes	More horsepower	More horsepower	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
Yes	Smartphone connection ability	GPS	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park
No	Smartphone connection ability	More horsepower	Virtual cockpit	Front-wheel drive	All-wheel drive	Self-park

Table 12: Questions regarding participants' preferences (Source: Author’s research)

The data from this group of questions will now be represented in charts. Starting off with the ability of participants' vehicles to achieve a connection with a smartphone.

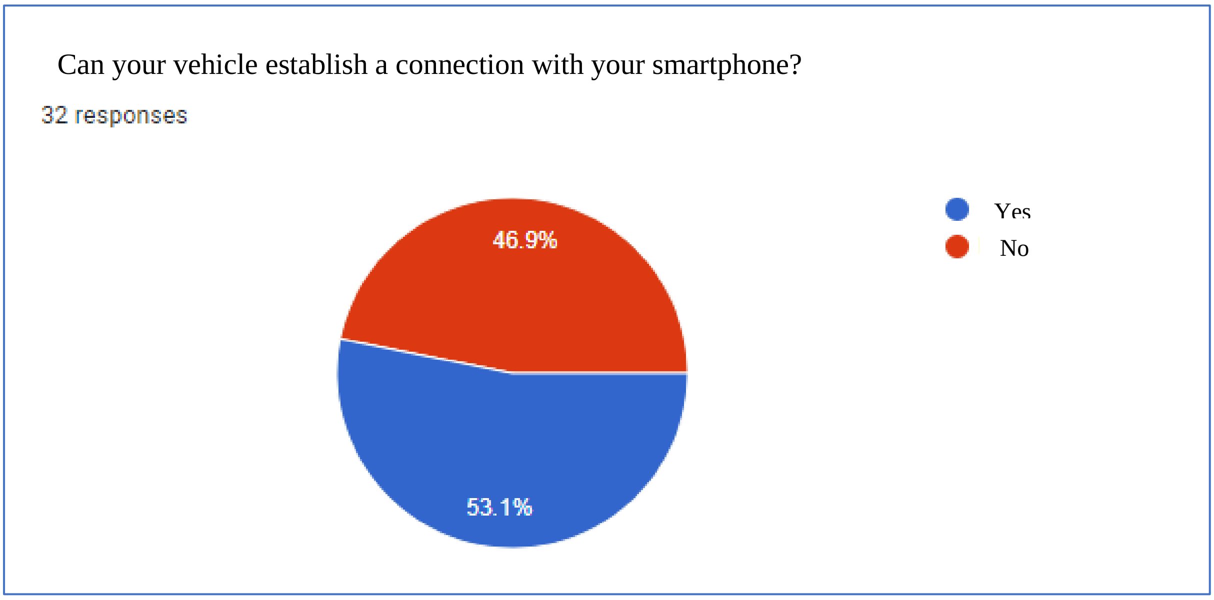

Figure 26: Can the vehicle connect to smartphone (Source: Author's research)

The distribution is pretty even, 17 participants can connect their phones, 15 can't. (Figure 34) The following five questions ask the participant if they would rather choose an engine with more horsepower, or one of the modern ICT systems available in cars. The first question asks if the participant would rather have a stronger engine or the ability to establish a connection with their smartphone. The majority (20 out of 32) would rather have a stronger engine. (Figure 35)

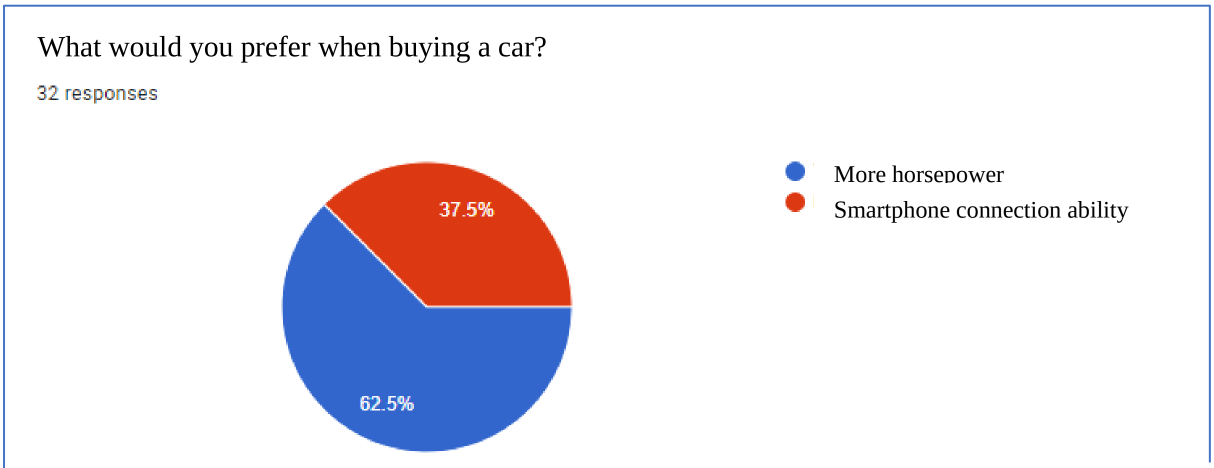

Figure 27: Preference between more engine power and smartphone connectivity (Source: Author's research)

Next, the participant is asked if they would rather have a stronger engine or a navigation system. Out of the 32 participants, 23 of them would choose a stronger engine. This was expected, knowing that everyone uses Google Maps on their smartphones. (Figure 36)

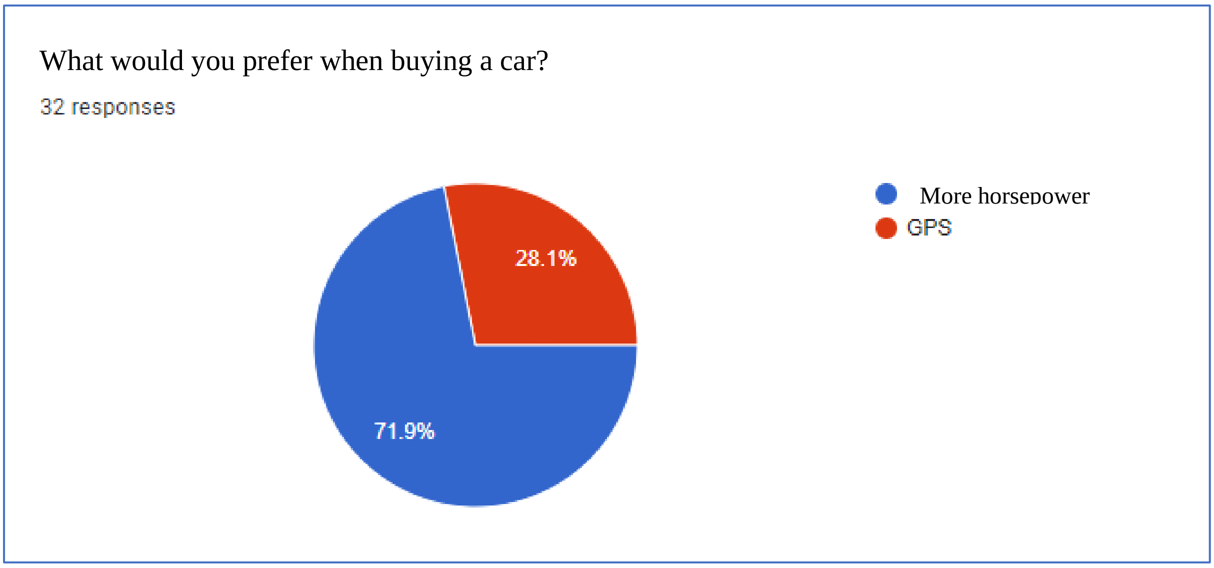

Figure 28: Preference between more engine power or GPS (Source: Author's research)

The next question (Figure 37) asks the participant if they would rather have a stronger engine or a virtual cockpit. Virtual cockpit is explained in the chapter 3.2. 62.5% of the participants would choose a virtual cockpit. Since a virtual cockpit is nothing more than one additional LCD screen in the place of the traditional analogue instrument cluster, which can display various kinds of data, an assumption can be made that the participants are more inclined to choose the latest tech system over a faster car.

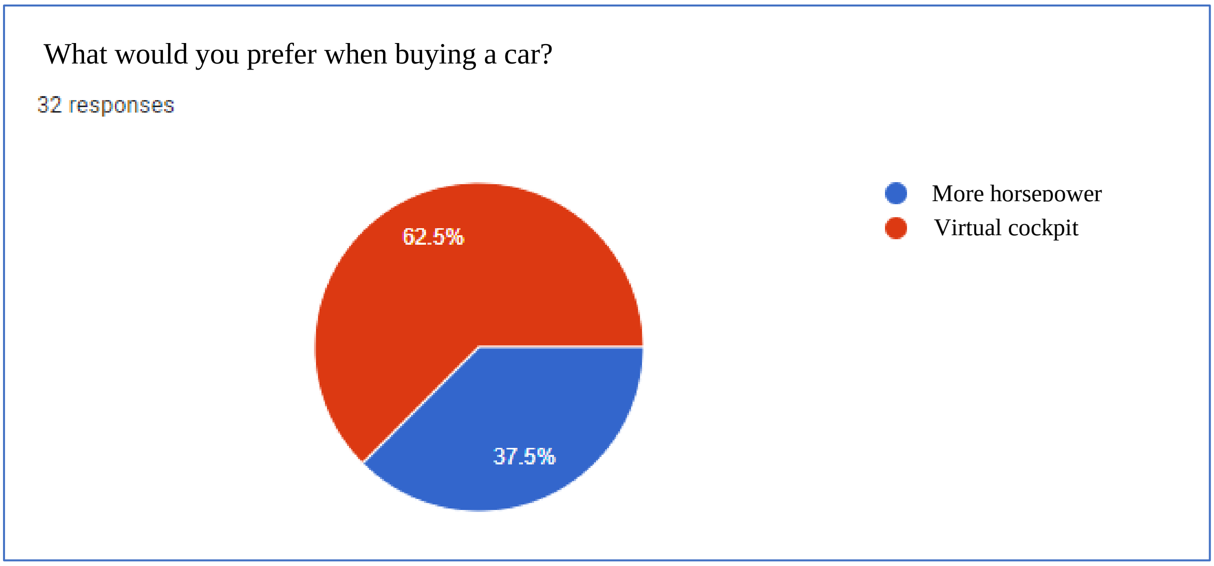

Figure 29: Preference between more engine power or virtual cockpit (Source: Author's research)

This is confirmed in the next question, shown in Figure 38, which asks the participant if they would rather have a stronger engine or all-wheel drive. 71.9% of them would rather have the latter.

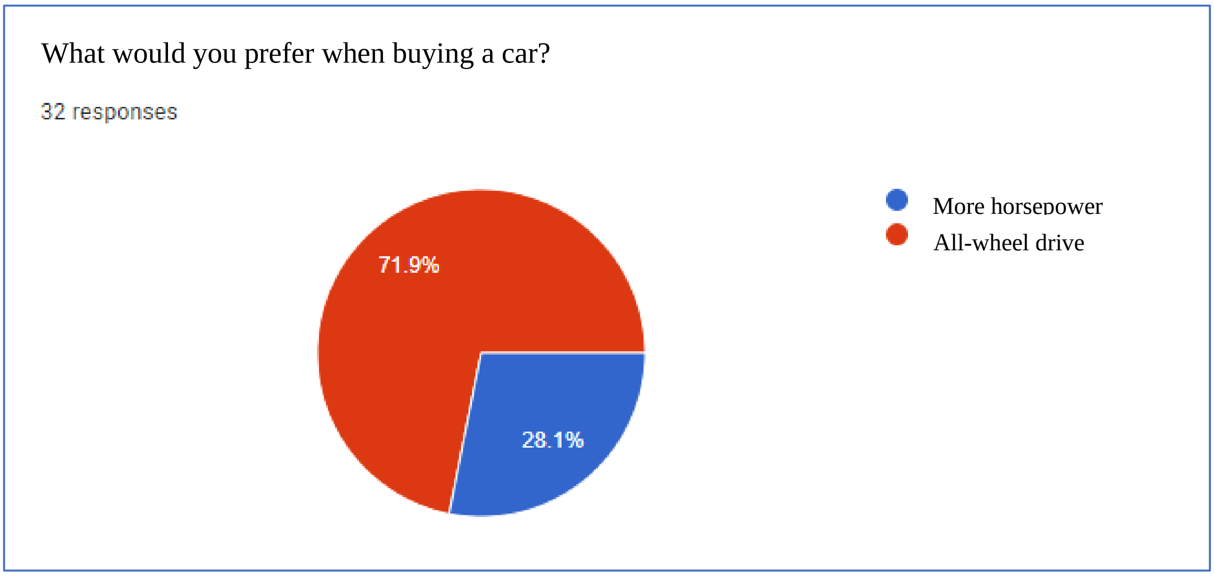

Figure 30: Preference between more engine power or AWD (Source: Author's research)

While it may not be apparent at first glance, but modern all-wheel drive vehicles, actually, require a decent bit of technological know-how to manufacture. It is very important to know the difference between four-wheel drive and all-wheel drive. Four-wheel drive vehicles can only lock their front and rear driveshafts so that each axle always turns at the same speed.[30] Modern vehicles, with all-wheel drive, have much cleverer systems. Some of them, actually, have four axles instead of two and can distribute power and torque to any wheel separately, depending on the situation. These systems make these decisions in a matter of tenths of a second and have complex algorithms that can make calculations and sense even the slightest

[30] Jacquot, J., (2016.): All-Wheel-Drive Systems Explained https://www.caranddriver.com/features/a15102281/best-all-wheel-drive-system/

wheel spin. The following question asks the participant if they would prioritise front-wheel drive or rear-wheel drive in their vehicle. (Figure 39)

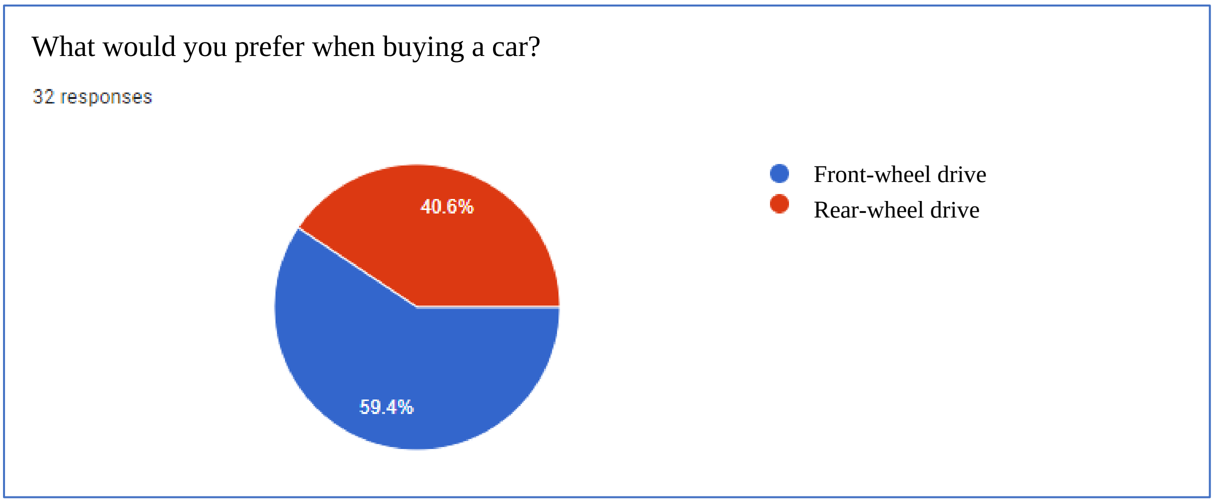

Figure 31: Preference between FWD and RWD (Source: Author's research)

As the graph shows, around 60% of participants would opt for front-wheel drive. FWD is safer and easier to manoeuvre than RWD and is technologically more complex to manufacture. In this day and age, it is a trait of sports cars to have RWD.

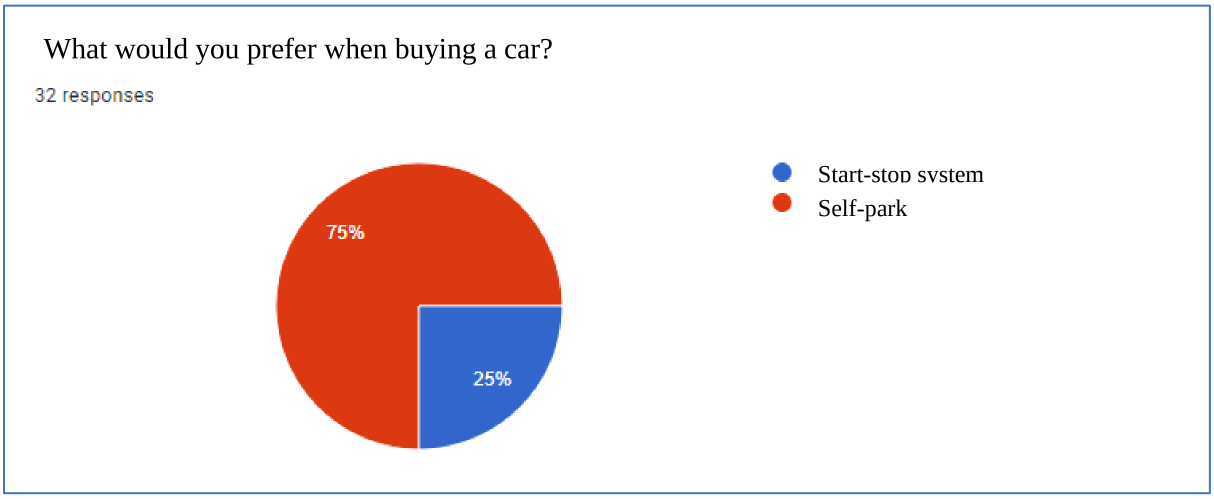

Figure 32: Preference between start-stop and self-park (Source: Author's research)

This question (Figure 40) let the aprticipant choose between two different ICT systems. The start-stop system, which turns the engine off, when the vehicle comes to a halt. That way, fuel consumption and CO2 emissions are reduced by removing unnecesary engine work-time. Self-park is one of the aforementioned levels of autonomy explained in a previous chapter. Self-park is a much newer functionality, with less tangible benefits, however, it is new and exciting. 75% of participants would opt for the self-park option.

The next table (Table 13) contains the last section of questions and asnwers.

How much would you trust full autonomy?	How much would you trust “lane-assist” technology?	How much would you trust “emergency braking” technology?	Would you drive an electric vehicle?	If you would drive an electric vehicle, what would be your reasons?	If you wouldn’t drive an electric vehicle, what would be your reasons?	If you payed 100,000kn for a diesel, how much would you pay for an electric vehicle at maximum?
3	3	3	Yes	Bla bla	Btk	120,000
1	1	3	No		High cost, short range of battery, long charging time	I wouldn’t buy an electric vehicle
1	5	5	No	0	Samo benzin amigo	I wouldn’t buy an electric vehicle
4	3	4	Yes	Isplativost	vozio bih ga	120,000
1	5	5	No	0	Nemogućnost prodaje, velika cijena nove baterije	I wouldn’t buy an electric vehicle
4	4	4	Yes	dobar izgled		150,000
3	4	4	Yes	Manji varijabilni troškovi.		150,000
2	4	3	Yes	Zbog smanjenja zagadenja okolisa	Vozila bih	150,000
1	1	2	No			I wouldn’t buy an electric vehicle
3	3	4	Yes		Premalo punjača, slaba infrastruktura, nedostupan za one koji nemaju kuću/dvorište i priključak za struju	150,000
2	3	2	No		Ne sviđaju mi se	I wouldn’t buy an electric vehicle
4	4	3	Yes	Poticaji, niza cijena odrzavanja	Osjecaj motora s unutarnjim izgaranjem	170,000
4	4	4	Yes	Udobnost, brzina, praktičnost, troskovi	Zvuk	150,000
3	4	4	Yes	Ne čuje se, ne zagaduje okoliš, jeftinije je od goriva		150,000
3	4	4	Yes	Ne troši gorivo, tiha vožnja, veliko ubrzanje		150,000
4	5	4	Yes	Potrošnja goriva, državna subvencija		150,000
4	4	4	Yes			120,000
2	2	2	Yes	usteda	kratki domet	150,000
3	4	3	Yes	Ušteda na gorivu.	Vozio bih, ali razlog koji me odbija jest pre mala zastupljenost punjača na hrvatskim prometnicama.	150,000
3	5	4	Yes	Ne troši gorivo, tih je, državna subvencija	Postaje za punjenje nisu dovoljno zastupljene, skup je	150,000
4	4	4	No	/	/	I wouldn’t buy an electric vehicle
3	3	3	Yes	Dugoročna isplativost		170,000
1	1	1	Yes	ne zagađuje okoliš		150,000

2	3	4	Yes	Cuvanje okolisa, usteda		120,000
4	4	4	Yes			120,000
3	3	3	Yes	Smanjenje emisije stetnih plinova		120,000
3	2	2	Yes	emisija CO2		170,000
3	4	4	Yes	Emisija plinova		150,000
3	4	4	Yes	Državni poticaj, tih je, ne troši gorivo	Manjak punjača	150,000
2	3	2	Yes	Ne mora se točiti, okoliš		120,000
3	4	4	Yes	manji troškovi, jednostavnije održavanje, manje kvarova	premalo mjesta za punjenje	150,000
4	4	3	Yes	Ne troši gorivo	Preskup	120,000
4	4	3	No		Izrazito loša infrastruktura, manjak poticaja, prevelika cijena, strah da kvara baterije, ne sviđaju mi se	I wouldn't buy an electric vehicle
3	4	3	Yes	Nema troška goriva, struja je jeftinija, tih je	Nema dovoljno punjača	120,000

Table 13:Questions regarding participants' opinions on modern ICT (Source: Author's research)

The following three questions required the participant to evaluate how much would they trust a new ICT system on a scale from one to five. The first question asked how much would the participant trust full vehicle autonomy.

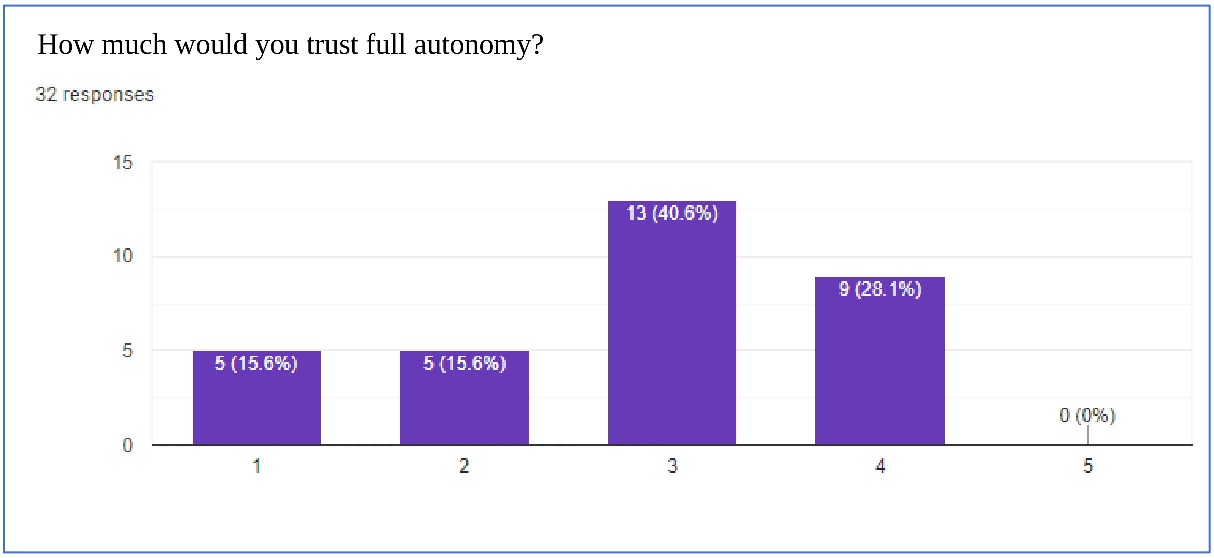

Figure 41: Level of trust towards full autonomy

It can be observed, that 40.6% of participants are somewhere in the middle between not trusting it at all and completely trusting it. Not a single participant would rely on full autonomy, 15.6% wouldn't trust it at all. 28.1% of participants would rely on full autonomy, but wouldn't be completely comfortable with it. (Figure 41)

This question is about trusting the lane-assist technology, which is also one of the levels of vehicle autonomy. Here it can be observed three participants who would be completely comfortable with relying on the vehicle's system to keep it centred. Majority (53.1%) would also rely on it, but not completely. There are also three participants who wouldn't trust it at all, even though it is currently being used on the roads legally. (Figure 42)

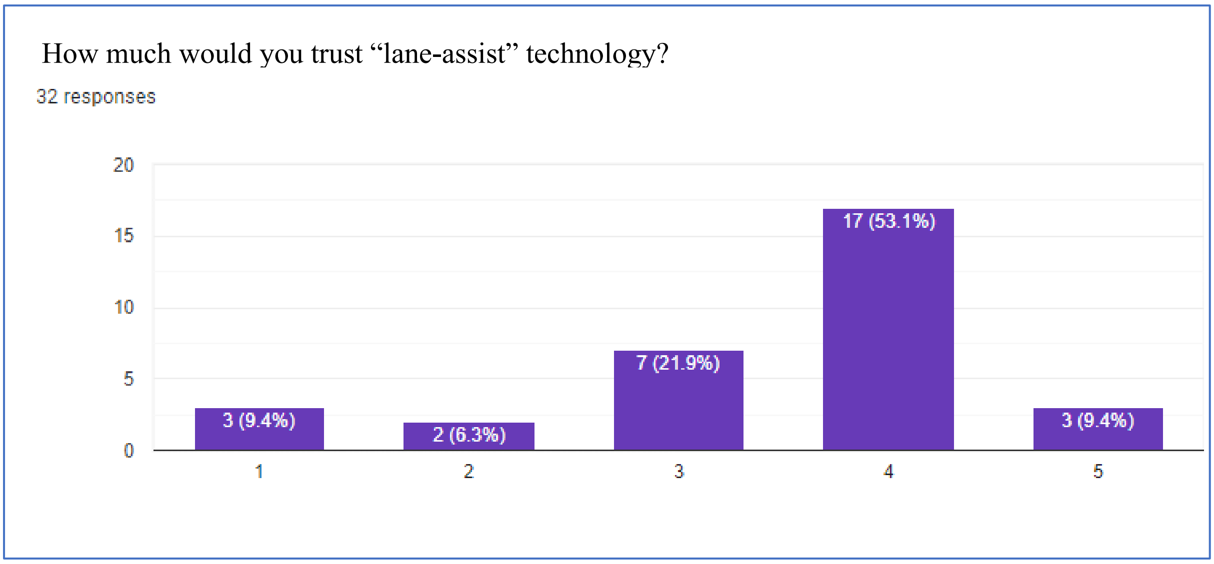

Figure 42: Level of trust towards lane-assist technology

Here, the participant was asked how much would they trust emergency braking technology. There is a similar distribution of answers as in the last question. The majority (46.9%) respondents would trust it 4 out of 5, only two of the would trust it completely, nine of them 4 out of 5, five participants wouldn't trust it most of the time and one participant would never trust that technology. (Figure 43)

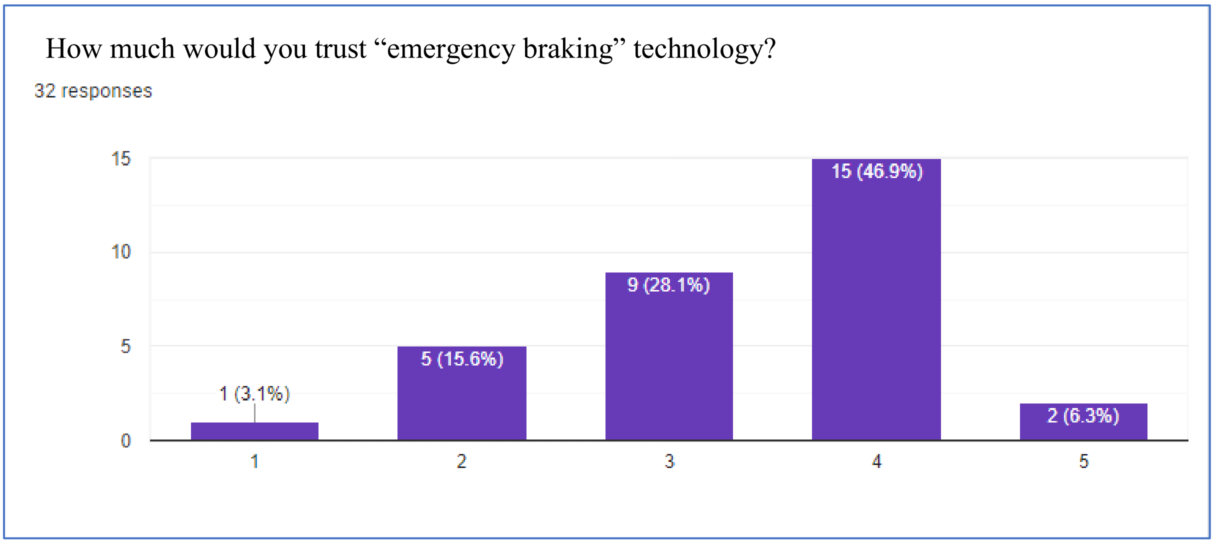

Figure 43: Level of trust towards emergency braking technology

The last four questions are about participants' opinions regarding electric vehicles. The first question is very straight forward; it asks the participant if they would drive an electric vehicle.

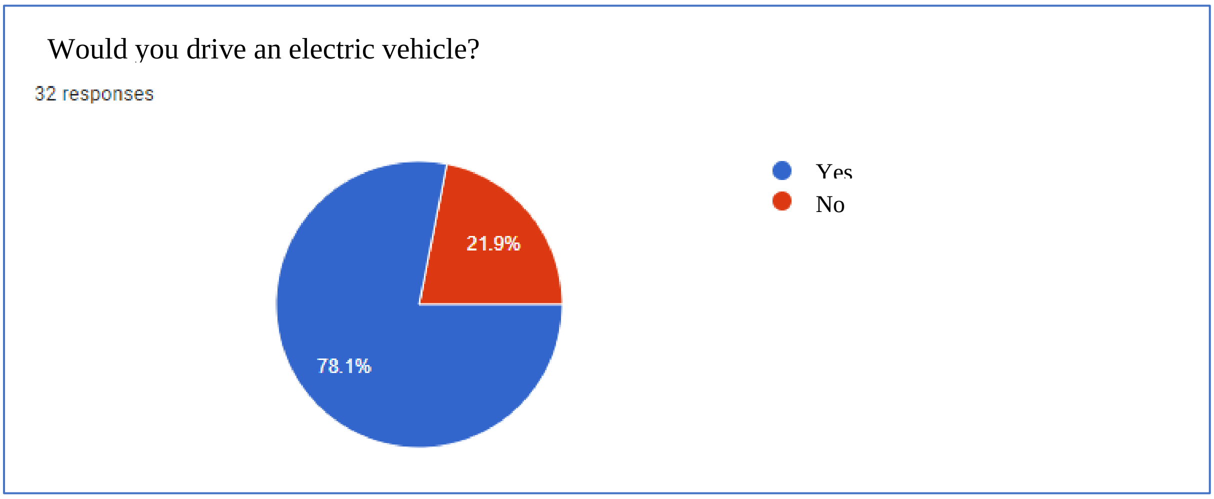

Figure 44: Question if participant would drive an electric car

Vast majority (78.1%) of participants would drive an electric vehicle, while 21.9% wouldn't. This question is not to be confused with asking the participants if they would purchase an electric vehicle. (Figure 44) The next two questions require the participants to provide a couple of reasons why they would or wouldn't buy an electric car. Among the 23 provided responses, 5 of them mentioned that electric cars are quiet, 14 respondents mentioned cost reductions (in form of fuel and in form of maintenance), 7 people had the environment and CO2 emissions in mind, 3 respondents mentioned the government incentive and 2 respondents recognised the immense acceleration that electric cars can have. The most prominent reason for not buying an electric car are lack of infrasctructure and charging stations, they might be hard to sell, they are expensive, it takes a long time to recharge, the short range of electric vehicles and fear of battery malfunction and having to purchase a new one, which would prove extremely expensive. Some respondents are, apparently, car purists and don't appreciate the lack of sound and internal combustion, thus they don't deem electric vehicle as a worthy drive.

The final question of the survey, shown in Figure 45, asked the participants if they were to pay 100,000kn for a diesel powered vehicle, what is the maximum they would pay for an electric vehicle. This question, basically, asks what additional percantage of money would they give up for an electric vehicle.

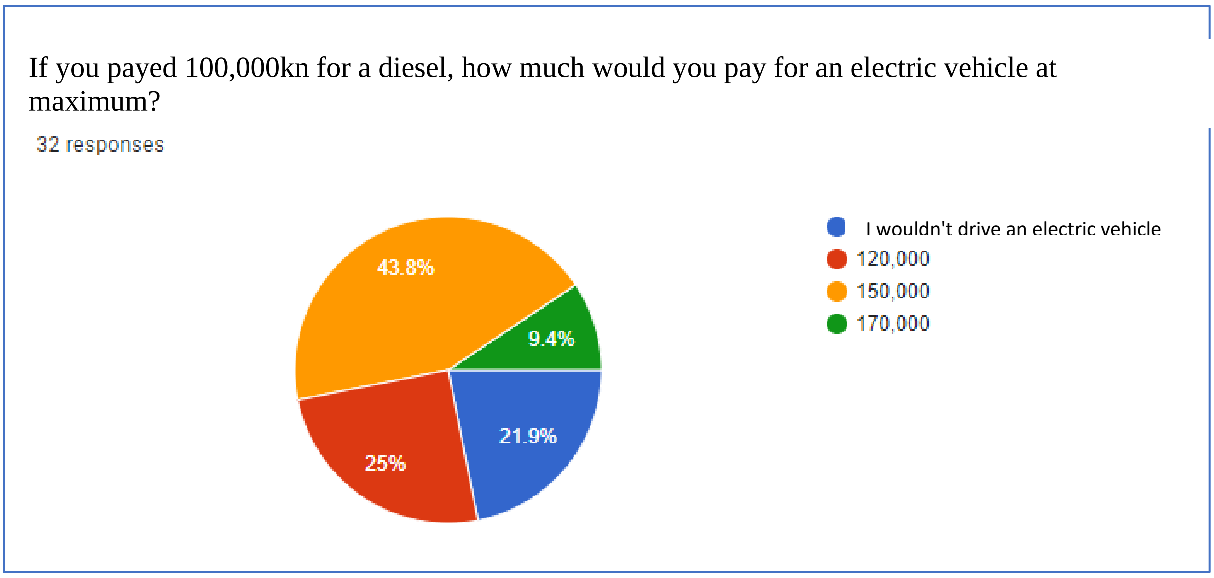

Figure 45: Additional budget for electric vehicle

Of the 32 participants, 43.8% of the them would pay 150,000kn for an electric car, which is a 50% increase in comparison to the suggested diesel. A fourth of all participants would pay an extra 20%, while only 9.4% were give up an additional 70%. 21.9% wouldn’t even consider an electric vehicle.

4.3. Discussion

Demographic characteristics

From the first section of questions it was discovered that most of the participants in the survey are aged between 18 and 25, with the other big chunk being under 30 years old. Majority of respondents are male. Almost 80% of participants have either bachelors or master degree, 43.8% are employed with a contract.

Brand

The data received from the survey can easily be compared to the official data received from CVH. It was proven that the two most prominent car manufacturers in Croatia are Volkswagen and Renault, same as in the official data. It can also be surmised that the average Croatian consumer prefers cars manufactured in Germany like Volkswagen, Škoda, Audi, Opel and Mercedes, with BMW being somewhat less popular. As one can see while driving on the city streets, hatchbacks are the most common car category. That can also be seen in the survey.

Vehicle age

20 of the 32 vehicles stated in the survey are hatchbacks, with an additional few being small city cars like Volkswagen Up!. While most of them were manufactured in 2015. and 2016., the calculated average age of the respondents' vehicles was 9.92 years, which is slightly less than the European average of 10.8 and the Croatian average of 12.6 years. The majority of respondents (75%), are not the first owner of their current vehicle. Some of them (59.5%) purchased their vehicles used and some inherited them from their family members. Most participants make about 10,000 km per year. There are only two participants with hybrid vehicles and not a single electric vehicle, which matches the statistics taken off the CVH website for 2019.

ICT preferences

If respondents' reasons against buying an electric vehicle are taken into account, it can be concluded that the government doesn't give nearly enough incentive for consumers to even consider buying an electric vehicle, aside from some consumers who are passionate about modern technology despite the high prices. About half of the participants can connect their smartphones to their cars, however most of them would rather have a more powerful engine. Most of them would also rather have a faster car, than an integrated navigation system. This is probably due to everyone already using Google Maps on their smartphones. Most people would choose more advanced ICT systems like virtual cockpit, self-parking and all-wheel drive, over a more powerful engine. This goes to show that consumers are more inclined to prefer modern technology than traditional car enthusiast traits like speed, acceleration or sporty engine sound. Looking at the last section, it can be surmised that people, generally, don’t trust vehicle autonomy, however a decent portion of them would be relatively comfortable giving up control to some automated systems like lane-assist and emergency braking. Most people would drive an electric car, however, they see issues in current high prices, bad local infrastructure, relatively short ranges compared to internal combustion engines and general fear of new technology, in a sense that they fear the expensive battery will malfunction and cause a very large expenditure. Participants would generally be comfortable with paying an additional 50% for an electric car. A fourth of them would give an additional 20%. This goes to show that consumers are generally interested in electric cars and can see enough benefit in them, so much so that they pay 50% more, however they find the issues of practicality more concerning than the actual price.

5. Conclusion

It can be concluded that the automotive industry does not have a future without the application of ICT. Manufacturers have already started to put the emphasis on developing new and exciting technological solutions. Just taking a look at the Volkswagen group and all the makes in their group, shows that all of their vehicles have the same couple of engines. They have 1.4 litre and 2 litre petrols and 2 litre diesel engines, any other engines like 2.5 litre petrols and 3.0 diesels belong almost exclusively to sport editions and luxury cars. The engine, horsepower, acceleration, piston alignment and similar purist traits are no longer selling points. The future of the automotive industry lies electric vehicles, automation systems, digitalisation and vehicle autonomy. The automotive industry creates 14.6 million jobs which makes up for 6.7% of all employment in the European Union and accounts for 7% of EU's total GDP. The European auto industry is a major global player, gaining €135.9 billion from extra EU exports.

Furthermore, manufacturers have started and should emphasise more on monitoring data collected from all of their vehicles. Serious thought should be given to the application of IoT in the industry and all the benefits it could grant. ICT is bringing us closer and closer to full vehicle autonomy, which will undoubtedly be a major turning point in the industry.

The Croatian government should reconsider their current incentives for electric vehicles, especially since speculation started about Tesla starting manufacture in Croatia. Moreover, Croatian average vehicle age is amongst the oldest, if not the oldest, in the European Union.

Finally, the research conducted revealed confirmed that consumers are generally more inclined to be more interested in the technological capabilities of their cars than its speed and acceleration. This trend will soon make the average car enthusiast boast about the extent of their car's level of autonomy rather than how long does it take to reach 100 km/h.

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7. Appendix

List of figures

List of Tables

Survey Questions

In the next part, all 30 questions will be presented along with their respective answers.

Age group *

- 18-25
- 26-30
- 31-40
- 41-50
- 50+

Gender *

- M
- F

Type of education *

- A.A.
- B.A.
- M.A.

Type of employment

- Permanent contract
- Temporary contract
- Student contract
- Unemployed

What is your monthly income

- 0-2,999
- 3,000-5,999
- 6,000-9999
- 10,000-14,000
- 15,000-20,000
- 21,000-25,000
- 25,000+

Car make *

Short-answer text

Car model *

Short-answer text

Year of production *

Short-answer text

Was the vehicle purchased used or new? *

- New
- Used

Which owner are you? *

- First
- Second
- Third
- Fourth
- More

What was the purchase price if the car? (HRK) *

- 30,000-70,000
- 70,000-100,000
- 100,000-150,000
- 150,000-200,000
- 200,000-400,000
- 400,000+

What is the total mileage? (km) *

- 0-20,000
- 20,000-40,000
- 40,000-60,000
- 60,000-80,000
- 80,000-100,000
- 100,000-150,000
- 150,000-200,000
- 200,000-300,000
- 300,000+

What is the average mileage per one year? *

- 0-10,000
- 10,000-15,000
- 15,000-20,000
- 20,000-40,000
- 40,000-60,000
- 60,000-80,000
- 80,000+

What are the CO_2 emissions? (g/km) *

- 0-39
- 40-69
- 70-79
- 80-89
- 90-99
- 100-119
- 120-149
- 150-179
- 180-200
- 200+

Which type of fuel is used? *

- Petrol
- Diesel
- Hybrid
- Fully electric
- LPG
- Other...

Which type of transmission is used? *

- Manual
- DSG (dual-clutch automatic)
- Automatic
- Continuously Variable Transmission (CVT)

Can your vehicle establish a connection with your smartphone? *

- Yes
- No

What would you prefer when buying a car? *

- More horsepower
- Smartphone connection ability

What would you prefer when buying a car? *

- More horsepower
- GPS

What would you prefer when buying a car? *

- More horsepower
- Virtual cockpit

What would you prefer when buying a car? *

- ◯ Front-wheel drive
- ◯ Rear-wheel drive

What would you prefer when buying a car? *

- ◯ More horsepower
- ◯ All-wheel drive

What would you prefer when buying a car? *

- ◯ Start-stop system
- ◯ Self-park

How much would you trust full autonomy? *

1	2	3	4	5
◯	◯	◯	◯	◯

How much would you trust “lane-assist” technology? *

1	2	3	4	5
◯	◯	◯	◯	◯

How much would you trust “emergency braking” technology? *

1	2	3	4	5
◯	◯	◯	◯	◯

Would you drive an electric vehicle? *

- ◯ Da
- ◯ Ne

If you wouldn't drive an electric vehicle, what would be your reasons?

Long-answer text

If you payed 100,000kn for a diesel, how much would you pay for an electric vehicle at maximum? *

- ◯ I wouldn't buy an electric vehicle
- ◯ 120,000
- ◯ 150,000
- ◯ 170,000