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EVOLUÇÃO PARQUE AUTOMÓVEL E COMO É QUE ELE AFETA O SETOR DE SERVIÇOS RÁPIDOS

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P.PORTO

CAR PARC EVOLUTION AND HOW IT AFFECTS THE FAST FIT SECTOR

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ABSTRACT

Multiple changes are occurring in the automotive sector, this thesis presents some aspects of the new era of mobility and presents the implications they will have on the automotive sector. This dissertation aims to show the evolution of the sector and how it will affect the aftermarket sector. Over the next decade, several trends threaten to constrain growth and shrink industry profit margins. Therefore, we will try to respond to the following topics: The evolution of mobility in recent years; Study the impact that new types of vehicles (electric, hybrid, others) have on the aftermarket sector and understand how the car fleet is changing at a Portuguese national level; Correlate the mobility trend with new data management and processing methodologies. It will also be demonstrated how data was collected to analyze the occupancy rate of a sample of workshops from a network in Portugal and how the forecast study for occupancy rates in the following months was carried out. A discussion of the highlighted topic is also presented, where we address the topic of future profitability of workshops in the quick service sector. Finally, we present a conclusion in which the limitations suffered during this work are also presented and future work is identified.

KEYWORDS

Aftermarket; Evolution; Data; Management; Mobility.

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RESUMO

Múltiplas mudanças estão a ocorrer no setor automotivo, esta tese apresenta alguns aspetos da nova era da mobilidade e apresenta as implicações que as mesmas irão ter no setor automóvel. Esta dissertação tem como objetivo mostrar a evolução do setor e como a mesma afetará o setor do pós-venda. Na próxima década, várias tendências ameaçam restringir o crescimento e diminuir as margens de lucro do setor. Assim, iremos tentar dar resposta aos seguintes temas: a evolução da mobilidade nos últimos anos; estudar o impacto que os novos tipos de veículos (elétricos, híbridos, outros) têm no setor de serviços rápidos e entender como o parque automóvel está a mudar a nível nacional; correlacionar a tendência da mobilidade com novas metodologias de gestão e processamento de dados. Será demonstrado ainda como foram recolhidos os dados para analisar a taxa de ocupação de uma amostra de oficinas de uma rede de em Portugal e como foi realizado o estudo de previsão para as taxas de ocupação nos meses seguintes. É tambem apresentada uma discussão do tema em destaque onde abordamos o tema da rentabilidade futura das oficinas do setor dos serviços rápidos. Por fim apresentamos uma conclusão final onde são tambem apresentadas as limitações sofridas no decorrer deste trabalho assim como são identificados trabalhos futuros.

PALAVRAS-CHAVE

Pós-venda; Evolução; Dados; Gestão; Mobilidade.

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LIST OF ABBREVIATIONS AND SYMBOLS

List of abbreviations

ISEP	Instituto Superior de Engenharia do Porto
P.Porto	Instituto Politécnico do Porto
ACEA	European Association of Automobile Manufacturers
BET	Battery Electric Trucks
BEV	Battery Electric Vehicles
CNG	Compressed Natural Gas
ECV	Electrically Chargeable Vehicles
EDV	Electric Drive Vehicles
EREV	Extended Range Electric Vehicle
ERS	Energy Recovery Systems
EV	Electric Vehicles
FCEV	Fuel Cell Electric Vehicles
FCHEV	Fuel Cell Hybrid Electric Vehicle
HEV	Hybrid Electric Vehicles
ICE	Internal Combustion Engine
ISEP	Instituto Superior de Engenharia do Porto
LNG	Liquefied Natural Gas
NGV	Natural Gas Vehicles
OEM	Original Equipment Manufacturer
OICA	Organisation Internationale des Constructers d' Automobiles
PHEV	Plug-in Hybrid Electric Vehicles
TTW	Tank to Wheel
WtW	Well-to-Wheel
OES	Original Equipment Supplier

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1. INTRODUTION

In this chapter the objective is to provide a real-life context of today's car sales situation, present some theoretical indications for future changes, introduce the main goals, methodology, internship location and the dissertation structure.

1.1. Contextualization

We are experiencing a new era of mobility. Following the problems with high emissions of CO_2 and its impacts in the environment, we now face the need to develop the automotive sector by adopting new technologies that give an answer to this problem.

Over the next decade, several trends threaten to restrict growth and diminish profit margins in the automotive aftersales market. Electric drivetrains, which require less maintenance, are becoming more prevalent in vehicle architecture. Collisions will be reduced as a result of driver aid technologies. Competition will increase due to new players and internet sales tools.

Even though business is recovering from the pandemic and will continue to expand for both independent aftermarket businesses and Original Equipment Manufacturers (OEM's) and authorized retailers, continuous market disruption and increased competition have put businesses at a crossroad. Because of the increasing technological complexity, the businesses that supply the independent aftermarket sales channel are at the greatest risk.

A key factor in the aftermarket sector is the proportion of business between authorized and independent supply channels and its changes following fleet aging. When a car is still under warranty or is relatively new, owners tend to take it to an approved repair facility. However, as their vehicles ages, they are more inclined to seek out a cost-effective solution from an independent workshop.

Multiple changes are on the horizon in the European aftermarket business and companies should consider strategic responses as they deal with wholesale consolidation, fleets and insurance companies proactively routing customers to preferred workshops.

1.2. Main Goals

This thesis wishes to provide an answer to the changes suffered in today's car parc. Electric powered vehicles are still a relatively recent technology in the car market world.

To accomplish the purpose of this work three main goals have been established:

- Establish the trend of mobility having in mind the last few years market behaviour.
- Study the impact that new types of vehicles have on the fast fit sector and understand how the car parc is changing on national ground.
- Correlate the trend of mobility with new management and data processing methodologies.

1.3. Methodology

In this dissertation the methodology adopted was based on the research of various bibliographic reviews related to the evolution of the car parc in the world.

A theoretical study was made about how the CO_2 emissions in the world connected to the need for change to a cleaner way of mobility. The study converged to the understanding of the new technologies available on the market and how cleaner they can be.

With the information collected, the study tries to understand how the after-sale sector will need to adopt new management models to be able to give a response to the new technologies in hands. The quick and continuous growth of new technologies implemented into vehicles creates new demands to the parts and technological side of the shops management, and ways of surpassing this new phase of problems will be analyzed.

A follow-up was carried away in the data processing systems that this industry has been using in the last decade to control the needs of their customers, with this, we would like to present the necessities that future markets will be forced to control to be able to conduct business to their workshops.

Following this analysis, the goal is to study how the aftermarket sector will be affected by these new types of mobility, and understand which developments are needed in the sector. Different problems will raise, and the technicians will need to be more familiarized with these new types of mobility to be able to satisfy their client’s needs.

1.4. Internship Location

This work was carried out at Midas Portugal a company under the administration of Salvador Caetano’s Group. Salvador Caetano is an international group that started its journey with bus parts production and car retail sales. In Portugal, they are the biggest retailer in new and used car sales, and since October 2020 they are also the master franchise of Midas Portugal. This internship was orientated by Ricardo Simões Chief Operating Officer (COO) and it lasted nine months [1].

1.5. Thesis Structure

This dissertation is divided into six chapters. The first chapter presents the introduction and the main goals, followed by the second chapter that introduces the literature review of this thesis. In the third chapter we have a presentation of the company. In the fourth chapter we have the presentation and collection of the date. In the fifth chapter we have the conclusions that are displayed with critical and relevant observations. The last chapter displays the information sources references and others.

2. STATE OF THE ART

This thesis presents a study of the car market and its evolution, the characterization of the car repair sector in Portugal, management models at car repair dealerships, and for data processing methodologies.

2.1. Study of the Car Market

In this chapter it is researched today's situation of the car parc, future changes, new management models and the updates needed in the data management in order to be ready for the implementation of new mobility technologies.

2.1.1. Evolution of the Car Market

Since the Paris agreement, on October 17th 2017, regarding climate changes, the mobility sector has undergone some changes in the way that mobility is done. The excess of emissions of CO_2 have led the industry to develop new ways of powering cars. Electrifying vehicles has been the main focus of many car brands. Matthias Wissmann, president of the *Organisation Internationale des Constructers d' Automobiles* (OICA), stated, during OICA general assembly, that electric vehicles offer an important alternative to internal combustion engines (gasoline and diesel), however it is not the only solution on a global scale. With this in mind, we can say that there are other alternatives to electric mobility, such as hydrogen and synthetic fuel, and this leads to a state of uncertainty about the future of conventional car mobility. OICA believes that any technology ban is the wrong path to achieve the main goal of equivalency between industrial policy and climate protection and that we must be open to technology [2].

Battery powered electric vehicles in today's market are still produced in limited quantities and have been used mostly in city centres where the zero emissions goal is the focus.

This thought might not be the ideal solution because electric cars sometimes are being charged using electricity produced by fossil fuels. This results in an annulation of the zero emissions standard and consequently less benefit of using this type of mobility. In addition to the question of how electric cars are charged, we must question the limited range provided by the battery technology. This is a limitation on their usefulness for the everyday user.

Although these questions remain to be answered, this technology still has its place on the market and it is believed that this will be the basis for fuel cell powered vehicles [3].

According to the European Association of Automobile Manufacturers (ACEA) the sales of alternatively powered cars need to pick up strongly if we want to achieve the 2025 and 2030 targets of CO_2 emissions. Table 1 shows the evolution of sales of Electric Vehicles (EV) cars [4].

Table 1 - Trend of Car Sales in Europe [4].

Designation	2014 (Un)	2015 (Un)	2016 (Un)	2017 (Un)	2018 (Un)	2019 (Un)
Petrol	5 358 452	6 036 564	6 800 116	7 563 739	8 521 418	8 964 034
Diesel	6 599 462	7 039 611	7 175 630	6 617 051	5 402 079	4 650 558
Electrically Chargeable	69 958	148 027	155 634	218 083	300 258	458 915
Battery Electric	37 517	59 165	63 479	97 667	147 428	284 812
Plug-in Hybrids	32 441	88 862	92 155	120 416	152 830	174 103
Hybrid Electric	176 525	218 755	278 729	426 769	598 462	896 785
Fuel Cell	38	176	123	253	266	535
Compressed Natural Gas (CNG)	97 214	78 511	57 609	49 553	65 023	68 581
Other (Liquefied Natural Gas + Etanol 85)	141 452	140 321	118 430	156 710	164 270	187 378

Nevertheless, the situation in today's market may be distorted because of the fiscal benefits that the government has given to national companies. With these benefits companies can save money, on taxes, buying these new types of mobility vehicles instead of the internal combustion engines vehicles. These fiscal benefits are presented in Table 2 and show the exemption, on taxes, that companies are eligible for when buying more sustainable vehicles.

Table 2 - Fiscal Benefits for Portuguese Companies 2021 [5].

VAT DEDUCTION					
Type of vehicle			Combustion	Electric	Hybrid Plug-In
Eligible for deduction			No	Yes	Yes
Max value to deduct			N/A	62.500€	50.000€
VEHICLES AUTONOMOUS TAXATION					
COST	Combustion Engines	Combustion Engines	Electric Energy	Hybrid Plug-In	Hybrid Plug-In
	Profit	Fiscal Charge	-	Profit	Fiscal Lost
< 27.500€	10%	20%	0%	5%	15%
27.500€ < 35.000€	27.5%	37,50%	0%	10%	20%
=>35.000€	35%	45%	0%	17,50%	27,5%
REDUCTION OF CIRCULATION TAX					
REDUCED PARKING CHARGES					

**Values according to the 2021 Portugal's State Budget (Valid for Companies)*

2.1.2. Vehicle Manufacturing Segmentation

Car manufacturers are investing in new ways of mobility. At the moment, it is possible to find in production cars that run only on fossil fuels, cars that are 100% electric, and even combined forms of mobility. The segmentation of these vehicles is explained below.

Segmentation:

- Electric Vehicles (EVs);
    - Electrically Chargeable Vehicles (ECVs);
        - Battery electric vehicles (BEVs);
        - Plug-in hybrid electric vehicles (PHEVs);
- Fuel Cell Electric Vehicles (FCEVs);
- Hybrid Electric Vehicles (HEVs);
    - Mild hybrid electric vehicles;
    - Full hybrid vehicles;
- Natural Gas Vehicles (NGVs);

- ELECTRIC VEHICLES:

Electric vehicles include electrically chargeable vehicles (ECVs) and fuel cell electric vehicles (FCEVs). Both are propelled by an electric motor but require very different infrastructure.

- ELECTRICALLY CHARGEABLE VEHICLES:

Electrically chargeable vehicles (ECVs) include full battery electric vehicles and plug-in hybrids, both of which require recharging infrastructure which connects them to the electricity grid.

  - Battery electric vehicles (BEVs) are fully powered by an electric motor, using electricity stored in an on-board battery that is charged by plugging into the electricity grid.
  - Plug-in hybrid electric vehicles (PHEVs) have an internal combustion engine (running on petrol or diesel) and a battery-powered electric motor. The battery is recharged by connecting to the grid as well as by the on-board engine. Depending on the battery level, the vehicle can run on the electric motor and/or the internal combustion engine.

- FUEL CELL ELECTRIC VEHICLES

Fuel cell electric vehicles (FCEVs) are also propelled by an electric motor, but their electricity is generated within the vehicle by a fuel cell that uses compressed hydrogen (H_2) and oxygen from the air. Thus, unlike ECVs, they are not recharged by connecting to the electricity grid. Instead, FCEVs require dedicated hydrogen filling stations.

- HYBRID ELECTRIC VEHICLES

Hybrid electric vehicles (HEVs) have an internal combustion engine (running on petrol or diesel) and a battery-powered electric motor. Electricity is generated internally from regenerative braking, cruising, and the combustion engine, so they do not need recharging infrastructure. The hybridization level ranges from mild to full.

  - Mild hybrid electric vehicles are powered by an internal combustion engine, but also have a battery-powered electric motor that supports the conventional engine. These vehicles cannot be powered by the electric motor alone.
  - Full hybrid electric vehicles are powered by both an electric motor and a combustion engine, each of which (or together) can power the wheels.

- NATURAL GAS VEHICLES

Natural gas vehicles (NGVs) run on compressed natural gas (CNG) or liquefied natural gas (LNG), the latter mainly being used for commercial vehicles such as trucks and the former for passenger cars. NGVs are based on mature technologies and use internal combustion engines. Dedicated refueling infrastructure is required.

In Figure 1 is shown today's standing point of the market share that these new technologies of mobility represent in Europe's car parc.

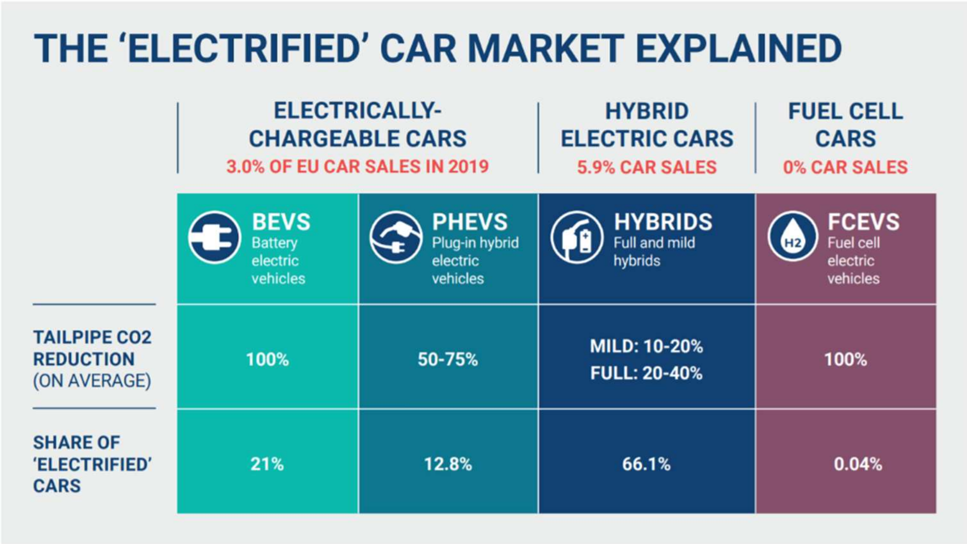


Figure 1 - Market Share in Europe (ACEA) [4].

Table 3 displays some articles that corroborate our perspective on the evolution of the car parc.

Table 3 - Car parc evolution references.

Reference	Work description
Patricia, Mário and Carla, 2010	This work researched the impact of fuel cell technologies in the Portuguese car market. Also, the authors tried to understand how this change in car parc would make a difference in the emission of CO_2. In this study the authors were able to conclude that in a full life cycle fuel cell vehicles emit less 20-40% CO_2 than conventional cars. CO_2 emissions can be reduced by 44% when running the vehicles, but this percentage is only 20% if a full cradle-to-grave analysis is accounted for [6].

Yorick, Heron and Hubert, 2018	In this study, it is presented a detailed breakdown of the energy conversion chains. In this case, it was considered BEVs and FCEVs. The wheel-to-wheel (WtW) analysis was adapted to a mobility grid that had in consideration the intermediate steps of useful electricity, energy carrier, and on-board storage. In today's markets the data showed them that, compared to FCEVs, BEVs and their infrastructure are twice as efficient in the conversion of renewable electricity to a mobility service. This work additionally shows that in these two EVs the infrastructure efficiencies are similar, with 57% from the grid to on-board storage and 66% for fast chargers coupled with battery storage. In the process of energy transmission, they were also able to estimate that 9% and 12% of the total energy is lost, respectively. Another subject that we must have in consideration is that the link between renewable electricity and mobility is not always converted into effective measures to guarantee this connection. Because of this, the scaling of renewable electricity production needs is underestimated and even for the hydrogen product they are blurred. In conclusion, the charging infrastructure is a major contributor to the overall energy efficiency of electric mobility. In this work, they were able to show that only 57-78% of the energy is effectively transferred to the vehicle. In further studies, the costs regarding infrastructure for electric mobility should be considered. For last, this study even considers that electrification should be extended to small lorries and buses [7].
Mehdi, Heikki, Oscar and Markus. 2021	This study concerns the evolution of electrification in cargo vehicles. Therefore, in this work, it is tested the reliability of implementing electrification in medium-heavy duty trucks. The analysis concerned the following aspects: charging activity BEVs on plug-in charging and ERS, geospatial data analysis based on charging activities, geospatial data analysis of regional power grid demand, and analysis of EREV technology adoption for road freight transportation. Battery electric trucks (BETs) may play a key role in mitigating emissions from the road freight transportation business, however, the most difficult obstacle to overcome is the limited range, long periods of charging, and cargo carrying capacity. In this study, they were able to conclude that trucks with a payload capacity of 30 tonnes have the most potential for electrification when considering today's market solution for batteries and plug-in charging. The expected rate of successfully supplying the considered gird (Finland and Switzerland) with these two technologies is 93% and 89% accordantly. In this work, they were also able to determine that even with high successful rates, there is still room for other technologies that could fill the gap for long haul trips. This study also indicates that the regional annual power grid load requirement

	maps could be used to calculate the impact that the grid will suffer in the future, or for other transportation grids in different countries [8].
Juan, Yuki, Mikiya and Seiichi, 2017	Electric Vehicles are emerging as less polluting alternatives to internal combustion engine vehicles. Therefore, it is important to assess their penetration in the vehicle market in the future. The approach used in this work was divided into two steps. The first is based on an optimization to estimate the 2050 vehicle market. The second step is to use a vehicle stock turnover to estimate the LDV energy and material consumption, CO_2 emissions and cost. In this work, they were able to conclude that in the base scenario, where costs are prioritized over other factors, the market share of HEV and BEV increases from 18,7% and 0,6% to 39,6% and 14,6 % by 2050. In 2050 market FCHEVs will dominate when low cost is prioritized while BEVs are the lower CO_2 issuers. Due to the late technology diffusion, it is predicted that ICEVs will have the largest stock share until 2038. Tank to wheel (TTW) CO_2 emissions will be reduced by 56.9% until 2050, but this will not be enough to achieve the long-term CO_2 emission reduction targets. However, the long-term target is achievable if EDVs are deployed [9].
Fuad, Sanjeevikumar, Lucian, Mohammad and Eklas, 2017	This work describes that the mobility trend nowadays is focused on the electric vehicles. And, in the near future, it is very likely that this electric mobility replaces all the internal combustion engine vehicles. EVs vehicles can cause a significant impact in diverse sectors. They are changing the power system and creating a huge instability in this sector. Meanwhile, this work states that if this technology is well implemented, EVs can be a major contributor to the successful implementation of the smart grid concept. As for the environment is concerned, this new era of mobility can introduce big benefits, electric vehicles are able to reduce the greenhouse gas emissions produced by the transportation sector. However, between all these benefits, there are still major obstacles to EVs to overcome if they want to replace ICE vehicles. This work focused on reviewing all the useful data available on EV configurations, such as battery energy sources, electrical machines, charging techniques, optimization techniques, impacts, trends, and possible directions of future developments. The goal was to be able to provide the overall picture of the current EV technology and their future in the sector. In this work, the authors were able to conclude that there is a great potential for EVs to become the future of transportation and that they can play an important role with regard to global warming. Although this technology has some limitations and there are several limitations to overcome through future developments, also assessed by this report, and

	provide a clear picture of this sector and the areas in need of further research [10].
Yue, Atriya, Romina, Zahra and Ali, 2021	Engines, as one of the vehicle's propulsion components, have a substantial impact on fuel efficiency and emissions. Four complimentary technical approaches to high-performance hybrid-specific engines are advanced combustion regimes, greener fuels, efficient operating cycles, and waste energy recovery. Low temperature combustion, alternate fuels, the overexpansion Atkinson cycle, and waste heat recovery have all been studied extensively on hybrid powertrain platforms over the years. This study provides a detailed evaluation of these four technical solutions from the perspectives of benefits, obstacles, and future prospects in order to determine the current research state and provide insights into future research potential [11].
A.G., Tabbi and Mohammad, 2020	This report studies the current state of the renewable energy automotive industry and states how fossil fuel dependency affects global emissions. The automotive industry is one of the largest producers of emissions that contributes to global warming. This work especially studies new developments and applications of fuel cells in vehicles and how they can benefit the sector by introducing measures that will limit the amount of emissions produced. The article shows that the study considered a thorough review of the future developments that are expected to be made in this industry, as well as, understanding the main impediments of the use of this technology nowadays. Therefore, after the analysis in this article, it is possible to conclude that even with multiple progresses made in fuel cell technology, there is still a lot to develop. Today's cost of implementing this technology in the automotive industry is a major drawback, and, for this reason, this technology requires more research and development work to be considered to achieve easier implementation of this mobility solution in future markets. The research and development also analyzed in this report, should be based on the optimization of fuel cells and the materials used in their production with the main focus of reducing the price of implementation [12].
Adrian, Lorenzo, Daniel, Sebastian, Adam and Marcus, 2021	This work has identified the changes that electrification and automation cause in the automotive industry after discussing the megatrends of electrification and automation. These changes include new technical parameters, which are relevant due to the novel technologies required by BEVs and AVs, and vehicle cost structures. The study focuses on the vehicle, its mobility, the necessary charging infrastructure, and the associated energy costs. In terms of the vehicle, the higher costs of BEVs over ICEVs continue to deter many people from purchasing electric vehicles today. Another issue is the limited vehicle range of BEVs, which is still inferior to that of ICEVs. Falling battery prices will result in nearly equivalent

	production costs by 2030, resulting in comparable prices for customers without any subsidies. The range gap between BEVs and ICEVs is predicted to narrow as a result of increased gravimetrical and volumetric density at both the cell and pack levels, according to the research review. This may help to alleviate future concerns about low ranges, making BEVs more appealing to purchasers. The TCO analysis demonstrates that BEVs are now more expensive than ICEVs in terms of mobility. Nonetheless, the estimate predicts that, starting in 2026, BEVs will be cheaper than other electrification solutions, bringing them to parity with ICEVs (such as PHEVs and FCEVs). Aside from the car itself, the charging infrastructure is a significant part of mobility. To compensate for their current inferior range compared to ICEVs, BEVs will require a countrywide charging infrastructure. Dynamic charging might be useful for long distances without large batteries, but it's usually too expensive for passenger automobiles, especially with battery energy densities rising. Finally, even if the production costs of fossil fuels are still cheaper than those of renewable electric energy, BEVs have a significant edge in terms of vehicle powertrain efficiencies. In conclusion, technological advancements and mass production are likely to reduce the actual disadvantages of BEVs in contrast to other propulsion systems in the future. As a result, BEVs may be able to evolve into an ideal mobility solution [13].
Jonas, Henrik, Patrick and Kay, 2017	The outcomes of this study back with previous studies, demonstrating that autonomous vehicles will provide significant improvements in accessibility. As a result, it is recommended that planning authorities take action on this issue in order to maintain control over the forthcoming disturbance. Furthermore, this study adds to our understanding of the competition between autonomous vehicles and public transportation. It demonstrates that, even in the most severe case, fleets of autonomous vehicles will be able to meet the whole transportation demand, which includes both automotive and public transportation need. Given that many characteristics of future autonomous vehicles are yet unknown, this study presents preliminary estimations of their accessibility impact. Despite the fact that the estimations of those accessibility implications are already worrying, when additional information on actual implementations and travel behaviour affects becomes available, the estimates of those accessibility impacts should be improved [14].
Xin, Hancheng, Pantao, Anying and Teng, 2021	With reference to the historical technical change in the automobile industry in the last century, this study illustrates the hopeful potential for carbon neutrality in private passenger automobiles through rapid diffusion of low carbon technologies. More crucially, the potential for significant emissions reductions through the development of new transportation modes and the reorganization of urban space extends beyond car technology rivalry. Aside from BEVs and

	FCVs, a variety of novel low-carbon personal transportation alternatives using intelligent technology are emerging to match various local circumstances. The transformation of the transportation sector's landscape may be more significant than strengthening the recycling sector to reduce platinum usage. Because the energy-material nexus is rooted in the context of multi-level technology transformations, such a transition necessitates a global rethink of the vehicle industry's goods and business model. To assist such a shift toward sustainability, an integrated, consistent, and coordinated set of policies is required [15].
Pandav, Sanjeevikumar, Mahajan, Vigna and Frede, 2021	The current status and prospects of personal effects coverage (PECs) in electric, hybrid, and fuel cell vehicles are discussed. The impact of PECs on the cost, efficiency, and performance of electric vehicles was summarized in this research. It is feasible to conclude from the review of EVs that the PHEV have the ideal combination of two energy sources for propelling and other tasks. With the progress of the vehicle electrical system, there is a greater requirement for diverse supply ratings, which can no longer be met by a single battery or a two-battery system. Finally, the study discusses the numerous issues that PECs face in terms of increasing efficiency, durability, performance, and lowering costs [16].
Mateo, Marta and Laura, 2022	As a result of the large influxes of retired EV batteries expected in the next years, this paper suggests that suitable management procedures must be introduced as soon as possible. In the long run, however, the growing longevity of EV batteries may reduce the number of batteries to manage. Extending battery lifespans through second-life applications like photovoltaic energy storage can encourage the purchase of electric vehicles as well as the generation of renewable energy for self-consumption in houses, all while reducing the demand for basic raw materials. Batteries can be recycled after a second life to recover precious materials and minimize reliance on imports from distant nations [17].
Debapriya, David S., David B., Bingzheng and Gil, 2022	The impact of neighborhood and workplace effects can help explain why many California locations with high incentives but little technology exposure continue to have poor adoption rates of PEVs. Because the efficacy of regulations and incentives aimed at growing the PEV market is influenced by neighborhood and workplace effects, stronger incentives may be required at the beginning of the market, such as in rural areas where there is no PEV exposure. The study findings imply that putting at least part of the chargers in high-visibility areas can promote market growth among commuters regardless of the density of PEVs near their residential location when designing charging infrastructure at commuting destinations [18].

Chi, Bảo-Huy, João and Minh, 2021	The research proposes a revolutionary comprehensive approach for optimizing the dual-motor off-road EV's drivetrain configuration. The dual-motor model's proposed powertrain architecture achieves the high driving performance required by the target vehicle. The proposed strategy is based on reducing the difference in power envelope between the targeted and dual-motor models. This groundbreaking technology offers a complete drivetrain design solution for high-performance electric vehicle designs. The proposed multi-step process appears to be promising for a wide range of electric vehicle applications. The torque distribution between two motors will be improved in a future study to maximize global energy efficiency. As a result, the dual-motor multi-speed gear vehicle should provide the best driving performance and energy efficiency [19].
Rui, Lei, Kangning, Xiaogang and Lu, 2021	In short, there are numerous factors to consider when determining whether electric automobiles can be produced in the long run. In the meanwhile, it should be supplemented with a thorough examination of the current situation. The most obvious point to note is that the technological greenness of electric vehicles does not always imply that they are more environmentally friendly because the win-win-win equilibrium state takes into account various aspects. The inability to estimate all the expenses associated with the marketing of green vehicles, such as the investment in charging stations and the recycling of used batteries, is one of the work's shortcomings. Furthermore, the impact of customer perception and cultural factors on customer purchasing behavior is impossible to quantify. Finally, fiscal assistance from the government will no longer be the only method to induce consumers to settle in [20].
Christian, Ana, Alessandro, Anastasios, Georgios, Ewan, Nigel, Arnulf, Kenji, Kensuke, Yasuyuki and Masafumi, 2022	According to the conclusions of this paper, it may be vital for PVEVs to incorporate characteristics relevant to climatic conditions in their certification or performance label, as is being recommended for PV modules in the European Union. This may be especially relevant for battery electric vehicles without VIPV, as their real-world performance, like that of internal combustion engine vehicles, is heavily influenced by environmental circumstances. Our proposed technique could be used as a first proxy for climate considerations [21].
Jing M., Yongfei, Shiang, Jing L. and Singuang, 2022	In this study, transportation vehicles are presented as a solution to problems with traditional decentralizing systems. The following are the primary conclusions: From the standpoint of safety and battery life, vehicle thermal management is essential even at normal temperatures under normal operating conditions; the control strategy formulated in this report is reliable and effective, based on the principle of optimal performance and energy conservation under the premise of safety and durability; The

	influence of temperature differences between battery and environment should be considered extensively when a thermal management control strategy is created, according to studies of cooling capacity and efficiency. The new studies have clarified the importance of actual available energy and battery temperatures [22].
Muhammad and Xiaowei, 2021	The results showed that BEVs could be a better option than ICEVs. As a result, there is a need to promote the usage of BEV and PHEVs, as well as support for public charging stations and financial incentives for EV customers, such as reduced vehicle taxes and purchase tax exemptions. From the standpoint of the automobile industry, there is also a pressing need to create lightweight, higher-mileage BEVs with lower energy usage, as well as infrastructural development (charging, etc.). Future BEVs should be cost-effective in order to compete with ICEVs in the market, hence promoting their adoption in the transportation sector [23].
Joshwin, Vinayak, M.J., K.A, S., Anish and Abhilash, 2022	Based on the findings, pure PCM-based BTMS will serve for maintaining the battery's operating temperature within an acceptable range at modest rates of heat generation. For applications with high heat generation rates, thermal conductivity enhancement techniques must be used to ensure that heat is effectively conducted to the surrounding PCM from the center to the outer PCM, reducing the temperature of the cells while also forming a more uniform temperature distribution across the PCM. This sort of battery thermal management system is most suited for electric vehicle applications when a large quantity of heat is generated in a short period of time, such as when the vehicle accelerates suddenly [24].
Murat, Nuri, Adeeb, Galal, Muhammet, Fajr and Gurkan, 2021	As a result, the findings of this study highlight the need of using decarbonized energy in the power mix to reduce emissions across all effect categories. Apart from the central European commission incentives, national incentives and advantages can help to boost EV adoption across the board. Belgium's monetary EV incentives, Denmark's EV registration tax benefits, France's lucrative scrappage plan for EVs, and Belgium's 100 percent ownership tax exemption for EVs emitting less than 50g CO_2/km are all instances of national incentives to strengthen EV adoption to maturity. Despite the promised benefits of subsidies to market the use of electric vehicles with the overarching goal of reducing carbon emissions, the case of Finland is surprising and a response to the research undertaken in this paper. When it comes to the adoption of electric vehicles, Finland is widely recognized for its lack of subsidies and tax benefits. Finland, on the other hand, is the best-performing country in the survey across all six scenarios. Finland's outstanding success can be ascribed to its post-2015 biofuel adaptation program and transition to intensive carbon neutral measures [25].

Ray, 2021	The investigation revealed that the consumption of automobiles in each of these classes is highly dependent on their weight. As a result, if the average weight of vehicles in the future EV fleet is much higher than that of today's EV fleet, projections of the grid's demand will have to be adjusted. I proposed two scenarios to get a ballpark estimate of likely future consumption: To replace conventional vehicles of equivalent size and power, EVs must first boost their average weight and horsepower. Second, as the new class of "supercars" grows in popularity, average weight and horsepower increase even more. On top of the extra 1182 TWh we might expect from an EV fleet that is essentially a larger version of the current one, these scenarios see annual increases of 166 TWh (14%) and 237 TWh (20%). This will boost demand on a decarbonized grid by 34% and 36%, respectively, rather than the 30% we would expect if future EVs had the same average weight as current models. Within the next two or three decades, policymakers must carefully explore how enough carbon-free electricity could be produced for such a fleet, let alone for current needs [26].

2.2. Characterization of the Car Repair Sector in Portugal

Nowadays the market, in Portugal, is shared by numerous players, the main ones are MIDAS, Norauto, Mforce, Roady, Firststop, Euromais, Feuvert, etc.

McKinsey’s aftermarket model provides information about future changes in the revenue pool.

The forecast indicates that global component revenue after 2030 will be split into two development scenarios. Both scenarios consider the different sizes of the car parc as well as the changes that the market will suffer related to technology development, government regulations, and customer attitudes. The scenarios analysed in this study are: one base scenario and a fast-paced scenario with two key variables, the overall size of the car fleet and the impact of varying technological trends and consumer attitudes.

The baseline scenario derives from a set of assumptions and in the point of view of the writer is the most likely to happen because of its alignment with the targets of CO_2 emissions and percentages of fleet sales. This assumption will have an impact on the growth of the car parc and will affect the share of different mobility car sales in the considered region until 2030. In this scenario is also considered the stability in regulation and technology trends. In the fast-paced scenario, it is described a reduced car parc scenario.

Regarding electrification, the fast—paced scenario assumes greater electrification of the global car fleet because it considers an elevated demand by the consumer for electric powertrains.

When it comes to autonomous driving, the presented scenario considers a higher adoption of autonomous driving technology related to a greater consumer acceptance [27].

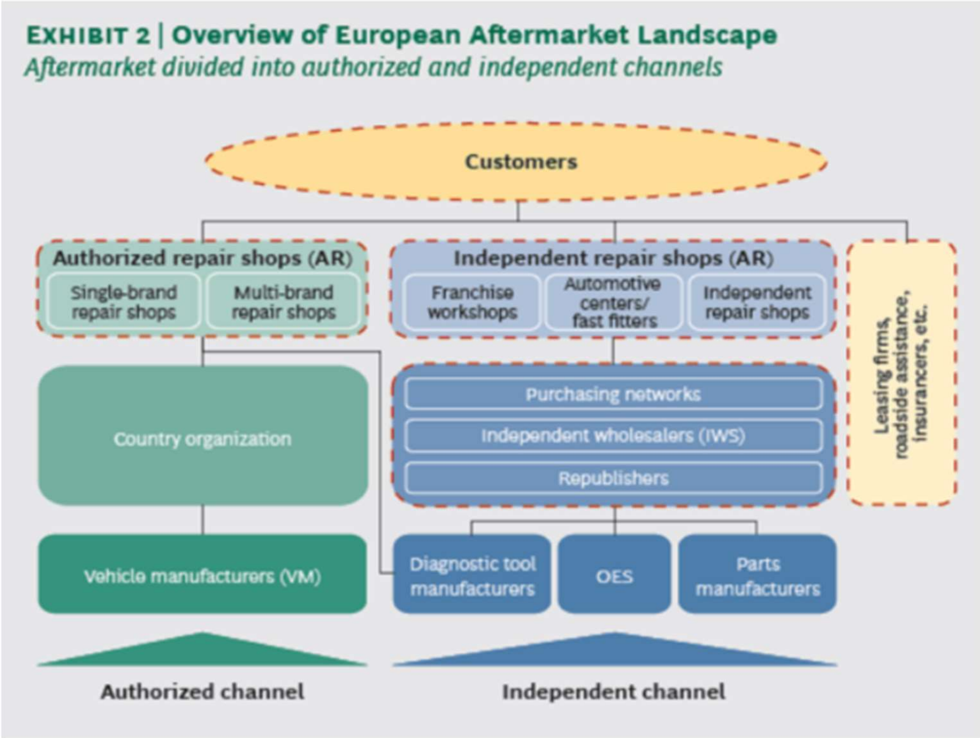
The baseline scenario predicts the global growth of components with a shift in the regional revenue pool. The size of the after sales market in 2019 was 213 billion $ in the USA, 87 billion $ in the four main European markets, and 163 billion $ in China. The outlook for the 2030 aftermarket is positive, with growing revenues in all regions. However, the foundations of the aftersales market will change, as shown by the slowdown in the growth of the car parc and the constant aging of it. This not only leads to an overall revenue pool increase of 3.5% per annum across three regions but also has an impact on overall growth and the relative share of each component category across regions. The Chinese aftermarket shows a growth forecast at the component-category level compared to the US and the four main European markets (United Kingdon, Germany, France and Italy). Despite the growth forecast for the four main European markets, multiple component categories will underperform market expectations. The highest percentage changes are expected in components, directly affected by electrification and autonomous driving, as these parts sales basically start from scratch. Negative changes in component market share will likely vary from region to region and will be seen in categories adversely affected by electrification and autonomous driving [27].

2.3. Management models at Car Repair Dealerships

The automotive aftermarket is a complicated, powerful, and fiercely competitive market that supports Europe's millions of cars, vans, lorries, and buses. From parts supply to fitment and servicing, the automotive aftermarket's multifaceted and diverse segments cover the whole repair, maintenance, and service spectrum.

Customers who use and own passenger cars and commercial vehicles are highly demanding, being 90% of customers happy with the market's repair and available options. They make informed selections regarding where to have their vehicle repaired based on variables such as cost, convenience, quality, and the vehicle's age/value.

Figure 2 shows an overview of the European split between authorized and independent aftermarket shops. With this presentation we can better understand how both, authorized and independent, channels are structured and what types of workshops exist nationally to serve each costumer.



** Original Equipment Supplier (OES)*

Figure 2 - Overview of European Aftermarket Landscape [28].

Consumer tastes aren't set in stone, and they shift as their car ages. As a result, car manufacturers do not have a significant aftermarket presence, and it is apparent that they only have a strong market presence for the first four years of the vehicle's existence. In any event, the early years of a vehicle's life are not a lucrative repair segment, and the majority of repairs are done under warranty.

The automotive aftermarket is made up of various aggressively competitive parties that provide various levels of service, ranging from the authorized networks of vehicle manufacturers, independent repairers, repair franchises, and a mix of original and non-original parts suppliers, to meet the wide range of consumer needs.

Repair businesses, both independent and authorized, exist in a range of shapes and sizes. Independent repair shop owners vary in size from large multinational organizations with locations around every corner to small family businesses around the block. The approved network of car manufacturers (OEM network) is made up of independently owned and operated small to medium firms (SMEs), contrary to popular belief. The number of OEM-owned repair shops is shockingly low. On the other side, there is clear evidence of aggressive consolidation in the independent repair industry, with a small number of organizations vying for more power and control.

The authorized repair networks, which are made up of small and medium businesses, are an important part of the entire aftermarket and provide a valued service to customers who appreciate quality, transparency, and competence. Customers choose to utilize the services of the approved repairer network based on their own set of criteria, just as they choose to use the services of the independent network.

Authorized repairers provide value by concentrating on a small number of brands and agreeing to meet the OEMs' high requirements for service, training, equipment, and customer service. This focus on quality repair and maintenance is what has resulted in constantly higher quality and customer satisfaction scores. Customers of authorized repair networks enjoy the OEM networks' openness in terms of price and parts quality. The assertion made by the independent operator lobby that vehicle manufacturers restrict access to vital VIN-based parts data is untrue. The OEMs offer the same repair and maintenance information to independent repairers as they do to licensed networks, and they comply with all legal obligations. In reality, in response to complaints from independent operators, both the Irish and German vehicle registration agencies recently evaluated the accessible repair and maintenance records from two OEMs and found no substantial flaws. When an independent repairer enters a VIN number, they will see the same components list as an authorized repairer. The demand for more information in various formats is simply an attempt by huge corporations to streamline business processes and increase revenues by selling components and services in the independent aftermarket.

The independent aftermarket industry is also raising concerns about present and future remote communications, diagnostic, and repair systems on automobiles. Despite the fact that all existing systems require the car owner/operator to select or accept a "preferred" supplier, the independent aftermarket lobby appears to believe that whenever a vehicle fault is discovered, the driver should be "bombed" with offers. Their forecast for a potentially dramatic shift in market share between licensed and freelance repairers ignores the systems' prior experience and present market realities. BMW has had remote diagnostic and communications technologies for almost a decade, yet its aftermarket business has not improved significantly during that period. All players should remember that these systems were created to improve the customer's driving experience, and that all aftermarket players have an equal chance to influence the car owner's servicing and repair decisions before a breakdown or accident necessitates immediate action [28].

Table 4 shows some references that are in line with the above text.

Table 4 - Articles of Management models for aftermarket industry.

Reference	Work description
Victor, Alain, Hélèna and Daniele, 2016	In this research, the authors looked at a difficulty that arose in the monitoring of a fleet of autonomous electric vehicles, and they created a scheduling strategy that reduces the total number of stops required to fulfil a set of pickup and delivery requests. The work has developed two distinct models and utilized them to establish boundaries and find the optimal solution for cases with up to 38 requests, which proved out to be extremely difficult to address precisely. They created a quick and effective hybrid heuristic that can be used to solve on-line or semi-online versions of the problem. To the best of our knowledge, this subject has never been studied in the literature before, therefore this study serves as a starting point for future research, particularly in terms of precise methods. Larger examples can clearly be solved using more advanced optimization algorithms based on the Branch-and-Price methodology, which likewise provide tighter constraints. Another avenue for additional research is to investigate various network topologies, such as trees or more complicated and connected ones, which may necessitate explicitly considering routing as part of the problem.

	Additional problem characteristics, such as time windows or battery charging schedules, may introduce fascinating elements to the problem that are relevant in practical implementations. Finally, the incorporation of algorithms in the online text may necessitate the real-time evaluation of algorithms with higher or assured performance [29].
Monica, Ioan, Jette, María, Amandine, Ada, Andromachi and Biagio, 2021	In terms of AV deployment scenarios, interviews with transportation and automotive specialists have revealed that the future is electric; additionally, it may be distinguished by shared mobility options, private mobility options, or a combination of the two. Experts also pointed out that ACVs may only make up a small portion of the vehicle stock in the future. Regulatory aspects, cybersecurity challenges, the transformation of the workforce and skills requirements of future employees in the sector, and the impact of system diagnostic features and preventive/predictive maintenance were all mentioned in the LR and expert inputs as additional relevant aspects that could shape the M&R of AVs. Another issue that requires additional research and proof is the possible structural alteration of the M&R sector as a result of the deployment of AVs. The advent of fewer, larger, and more specialized suppliers with greater access to data and information collected by car sensors, in particular, could be harmful to the evolution and expansion of small and medium-sized businesses in the industry. While there is enough information to identify the implications that BEVs will have on the automotive M&R sector, the early stages of complete vehicle automation deployment make it difficult to gauge the influence that such technology will have. As piloting and testing efforts progress toward full automation, more study should be conducted to gain a better understanding of the overall impact that such technological disruption will have on the M&R sector [30].
Saedaseul and Deok-Joo, 2019	Electric vehicles (EVs) are seen as a viable option for creating a carbon-free future. Consumer apathy is one of the most significant barriers to EV adoption. That is, most buyers focus solely on the initial purchase price, unaware of the whole life cycle cost in terms of long-term operational cost reductions. This study proposed a novel method for assisting clients in making financial decisions. However, non-economic factors like as the number of charging stations accessible, charging times, and environmental attitudes influence consumers' purchasing decisions. These intangible costs could be included in a consumer investment model for electric automobiles in the future. One of the more surprising conclusions from the sensitivity analysis was that the average yearly driving distance is the most important element in determining whether or not to replace an aging car with an EV, which is consistent with earlier research. As a result, it appears to be preferable to prioritize the adoption of EVs as public or commercial transportation vehicles, such as taxis, buses, and trucks. This study offered a new approach to assist customers in making economic decisions. However, several non-economic factors influence consumers' purchasing decisions, such as the quantity of charging stations available, charging

	times, and environmental attitudes. Future study could include these intangible costs in a consumer investment model for electric vehicles [31].
Albert, Manfred, Robert, Jonas, Frank, Antti and Zoran, 2021	BCG worked with the European Association of Automotive Suppliers and Wolk After Sales Experts on a comprehensive study to identify the industry's difficulties and the strategic remedies that companies should consider. They have performed over 600 interviews with service center operators across Europe and over 30 interviews with aftermarket industry officials. In conclusion, to remain competitive in an increasingly competitive market, companies must adapt to changing market conditions brought on by the industry's digitization, vehicle electrification, and increased channel competition. The data stream created by the digitalization of autos and aftermarket procedures must be tapped by players across the spectrum. They must deal with new competition introduced by e-tailers and other digital competitors, as well as carve out a role in increasingly integrated business alliances that will channel both customers and parts to workshops [32].
Patrick, Francesco and Kay, 2016	Automated vehicles (AVs) hold a lot of potential for the future of mobility. One of them is a reduction in the total vehicle fleet size necessary, particularly if AVs are mostly used as shared cars. This report has identified that two of the most critical next phases are the construction of a redistribution system and the installation of network routing (see above). However, for AV fleet study, it is likely more vital to first solve the limitation of using a static demand. New mobility offers and changing mobility prices influence transportation demand. These new offers must be able to respond to demand. Because they make travel more comfortable and affordable, AVs may increase demand. These aspects of convenience and affordability may cause people to switch from public transportation and sluggish modes to autonomous vehicles. Such shifts in demand may push the transportation system to its limitations, lengthening AV travel times. These longer travel times would, in turn, have demand-reducing consequences, bringing the system back to a new equilibrium. Investigations utilizing simulation frameworks capable of explicitly accounting for such effects are required to determine how these effects interact, what the new equilibrium looks like, and what the answers to these questions entail for infrastructure capacity requirements. If it is assumed that the simulation of AVs is also directly included in the framework, MATSim is intrinsically capable of modelling such complicated interactions. MATSim was utilized to generate only the initial demand for the time being, as it is not currently capable of simulating AVs. However, if AV modelling is adopted, a more detailed picture of the impact of AVs on the global vehicle fleet will be possible [33].

Mustapha, Amanda, Yoram and Joan, 2021	The purpose of this study is to start a discussion among scholars on how to expand on the existing body of knowledge to solve these challenges. For example, having researchers agree on a definition of an autonomous vehicle, its attributes, and whether or not it allows manual driving could assist survey studies provide more consistent results. Similarly, there is little agreement on what adoption entails and which service models (ownership, sharing, or mobility as a service) should be considered. Furthermore, rather than making assumptions about changes in travel behaviour, researchers utilizing agent-based and travel demand models can use results from survey studies and field experiments as input to their models (e.g. value of time, demand, mode share, etc.). Finally, there should be greater synergies between travel behaviour researchers and cities and companies creating and testing AV technology on the one hand, and cities and firms producing and testing AV technology on the other. Field experiments would be more realistic as a result, and biases in present studies would be eliminated. To summarize, automated vehicle technology has the potential to transform our lives, and understanding its implications is critical to reaping the benefits and minimizing the costs associated with it. The only way to do so is for researchers to collaborate and work together to improve the design of research on automated vehicles by building on the intelligence gathered and lessons learned from the current literature [34].
Carlos, Francisco R. and Francisco V., 2021	The automotive industry is undergoing a digital transition that will drastically alter the sector's worldwide landscape. Furthermore, it is generating a dramatic shift in the way car manufacturers and service providers distribute goods and services to the market, which is aided by government environmental legislation and high consumer demand. The findings give light on the impact and adaption options for digital transformation in the automobile industry, which is examined from multiple perspectives. In this regard, this work outlines the factors and actions that actors believe are necessary to promote the digitization process and, as a result, its efficacy in the production, sales, and connecting processes with users/clients. As a result, companies that take the lead in developing innovative digitalization-related services and products will have a considerable competitive edge in the automobile industry. As a result, the findings show that proper measures for digital transformation adaptation must be invested in, and that manufacturers will benefit from increased profits, productivity, and competitiveness as a result. The findings lead to the conclusion that vehicle manufacturers need make a significant investment in digital transformation in order to achieve a competitive advantage in the global market that represents the automotive sector. This investment should include funds for infrastructure projects as well as research, development, and innovation (RDI) efforts [35].

Evaldo, Peter, Liqiao and Gustavo, 2021	From a regulatory standpoint, the industrial confluence discussed in this study may be aided or hampered by the current regimes. Around business model innovation, there are broader considerations such as energy security, safety, and the need to minimize consumer lock-in, to name a few. In a broad sense, policy packages that handle both the electric and automotive aspects are required, which will flow into transportation, infrastructure, housing, and other relevant industries. Policy frameworks must be dynamic and quick to respond in a dynamic environment with high levels of technical and business model innovation, while still ensuring adequate continuity to promote critical investments [36].
Sehoon, Timothy and Cheongyeul, 2021	To improve acceptance, the outcomes of this study may suggest that it is critical to deliver appropriate information quickly and accurately "perceived" by the client. Businesses must communicate that information that was previously only available in traditional storefronts is now available and realized in real time thanks to technology. In traditional automotive retail, precise data on prices, inventory, and promotions has not been exchanged directly across regional merchants. The success of omnichannel Buy Online & Pick up in Store (BOPS) is dependent on real-time information, transparency, and a smooth experience. A customer group's differentiated strategic approach could be examined. Accepting BOPS is not difficult for clients with a strong proclivity for innovation. However, if a service does not reflect the customer's degree of acceptability, it may be ineffective or fail. Other retail forms must be researched. The adoption of BOPS may have a number of ramifications for the retail business model, and the retailing industry may seek alternate purchase choices. Depending on how they determine the buy-fulfilment structure, traditional automobile retail can build optimal and differentiated business models such as traditional showroom, delivery & pick-up center, display center, and online logistics center. Depending on criteria such as population density, geography, distance between stores, and consumer spending power, business optimization can be hastened [37].
Steffen and Frank, 2022	The goal of this study was to provide an overview of how product-service systems (PSSs) can be evaluated in the context of strategic planning and to identify how the challenges of strategic planning of product-service systems in the automotive industry can be addressed, motivated by the increasing role of PSSs in the industry. In general, the automobile industry's move to a PSS oriented business model is accompanied by a variety of strategic planning issues. The complexity of PSS's business models, as well as the growing importance of technology and its repercussions on the organization, must also be considered. Major viewpoints of PSS evaluation include economic, social, and environmental sustainability, costs, uncertainties, technology, and organization. Finally, the research findings are transferable to other industries due to the vast reach of the database search and the fact that the automobile business was only minimally targeted by the researched articles. In the automotive industry, for

	example, several new business models are now emerging, such as car sharing and hailing. As a result, a change toward mobility provider business models has resulted in a greater focus on new costs and income sources in the car industry. Furthermore, due to political and social pressures, particularly in the EU, the environmental issue in the automotive industry is likely to be even more important than in other industries [38].
Sunil, Manu, Anil, Sudhanshu, Eva and Sachin, 2021	C-SC is a new area of study that can be used to investigate interdependencies and synthesize important functions, resources, data, and capabilities. In today's dynamic economy, any organization must overcome these obstacles in order to establish C-SC enabled circular supply chains. The study's findings suggest that governance hurdles (GOB) and contextual barriers (COB) are the most significant roadblocks to cross-sector collaboration and circular development. The study has highlighted the cause-and-effect group obstacles that policymakers must take into account. The study demonstrates the relevance and causative nature of contextual, perceptual, and governance barriers, as well as the impact of effect group barriers, such as operational, strategic, and management obstacles. Because social issues are complicated and impossible to solve by one organization alone, any solution will require multi-faceted, multi-sectorial, and multi-approaches. Long-term relationships with high levels of interdependency, risk sharing, common goals, and collaboration for mutual gain can be encouraged through C-SC. Managers would benefit from investigating the strength of C-SC because it can help them increase the efficiency of their systems and make better decisions. The ramifications of these findings for policymakers dealing with governance and environmental challenges are significant. The study's main contribution is to conceptualize C-SC in the context of integrating CE philosophy with supply chain management, which is a new frontier in supply chain sustainability research and practice. The development of a theoretical framework based on different organizational theories to identify impediments to C-SC for CSCM is the second key contribution [39].
Ruchi, Rajesh and Nripendra, 2022	The study underlines the relevance of environmental orientation as a starting point for adopting a goal of sustainable consumption and production. Using the SAPLAP paradigm, the study offers a unique viewpoint on a company's attempts to achieve a sustainable consumption and production target. Sustainable consumption and production practices have become critical in light of growing concerns about environmental degradation, industrial waste, and climate change. In the automobile business, multi-stakeholder collaborations and partnerships are commonly employed to achieve sustainable consumption and production goals. The SAPLAP model has been proven to be quite effective in gaining a better knowledge of several aspects of sustainable practices in the Indian auto sector. End-of-vehicle management, reverse logistics route optimization, and market

	communication regarding green products and processes are among the topics highlighted. Automobile companies' total performance will most certainly improve as a result of information and coordination management difficulties at various levels, as well as the required paradigm shift in view of sustainable growth. The main contribution of this study to the literature on sustainability research is the discovery of a positive relationship between environmental orientation practices and environmental collaboration mechanisms, as well as relationships between environmental collaboration practices and capabilities required for sustainable production and consumption, corroborating previous studies that suggest that environmental orientation practices enable firms to engage in sustainable production and consumption [40].
David and Nizar, 2021	The literature underlines the systemic and complicated nature of electric car technology when it comes to general business model elements. Successful business models do not emerge from a single actor's perspective, but rather from a multi-actor perspective. Clearly, business models that work effectively with traditional technologies cannot be translated to the new environment without adjustments and coordinating actions among system actors. The chicken-and-egg problem, in particular, should go hand in hand with charging infrastructure; the chicken-and-egg problem remains a substantial impediment to the widespread adoption of electric vehicles. Governments establish public policies to assist electric vehicles in an attempt to mitigate the chicken-egg conundrum and share risks with businesses. Despite the fact that subsidies are primarily used to create technology for novel value propositions, entire business models should be viable in the long term, even without government assistance. In other words, companies should be able to show that their business models are financially viable even after they have been funded [41].

2.4. Methodologies for Data Processing

Car dealerships and auto repair businesses have a distinct set of issues when it comes to customer service and relationship management. While nostalgia for the "good old days" of automobile sales and service may bring back pleasant memories, it will not propel your auto business forward.

Fortunately, there are plenty of automotive customer relationship management (CRM) solutions to choose from that can help you streamline, simplify, and lead your company toward a prosperous digital future. Some CRM platforms will be dedicated solely to customer relationship management, while others will be integrated into a comprehensive Dealer Management System (DMS). You can also locate industry-specific and generic CRM systems that may meet your requirements, your requirements define which one you will choose.

Many dealers and repair shops have been hesitant to implement digital technology for customer relationship management and other day-to-day operations because of the challenges. Dealerships and repair shops operate in a particular way. They're selling goods and services, managing customers and vehicles, and dealing with a variety of various business operations all at the same time. There are other areas where current approaches fall short, such as appointment scheduling, payment integration, customer information sharing between departments, and other concerns. To solve this issue softwares were developed to help companies manage all these information in one place, they are often referred to as CRM.

Most of CRM solutions are built to work with the rest of your technological stack. If they're correctly tailored to the auto sector, they'll have a powerful platform with a number of customer management tools, analytics, and data sharing resources, ensuring that everyone is on the same page. Some platforms also provide customizable, scalable solutions that can scale with the company.

Scouring the Internet for the greatest CRM for your car repair shop or dealership we were able to understand that some of the software were built expressly for the automotive industry, while others are general-purpose platforms with useful features. Some of the CRM used in the industry are: Keap, Freshworks, HubSpot, Oracle NetSuite, Salesforce, DealerCenter, IDMS, ELEAD, Pipedrive and Agile [42].

Table 5 displays some references that give more insight in data processing methodologies.

Table 5 – Articles of Methodologies for Data Processing

Reference	Work description
Shirin, Sajjad and Mostafa, 2018	Given the modern era's competitive economy and extensive supply chain links, it's critical to consider both internal and external risks. Furthermore, proper methodologies for assessing these risks must be devised. The goal of this study is to develop a map based on artificial neural networks that can be used to assess and classify the risk levels of retailers with interconnected regulations in the supply chain. The study was divided into two phases: identifying the risk categories with the highest priority and quantitative descriptions of risk levels in the aftermarket industry and using the SOM technique to classify and assess the risk levels of retailers from a distributor's perspective by using their purchase records. SCRM is a well-known approach for managers and researchers to improve the supply chain's performance and efficacy. Because there are risks in every section of the supply chain that can possibly influence the entire supply chain, disregarding or even partially applying this method could result in irreversible damage to many supplies chain sectors. The neural network technique was used in this study to analyse the risk levels of merchants. This methodology has been utilized for risk assessment in a variety of sectors and businesses, indicating that it is widely used. Despite the prevalence of numerous risk assessment methodologies, one of the reasons for choosing this method in the current study was its utility as a tool for people with less specialized knowledge, as the primary output of SOM is visual maps, from which specialists can easily extract information. The results revealed the model's usefulness in assessing retailer risk levels at the organization. In addition, both the research and expert teams were pleased with the results. Other risk groups associated

	with retailers should be examined in future studies, according to the authors. The presented model can be used in both the downstream and upstream of the supply chain in many sectors to select and analyse every partner, such as suppliers and distributors, by using different input parameters that describe the situation and expert opinions. Additionally, the findings can be used as input to decision support systems for a hybrid risk assessment model and advanced evaluation procedure. Furthermore, the SOM classification strategy can be used in conjunction with other methods to tackle problems in the multiplex supply chain as a hybrid approach [43].
Joakim and Patrik, 2018	The goal of this article is to investigate and propose how product-in-use data might be used in the demand planning process for automotive aftermarket services to improve its performance. Design, methodology, and strategy by conducting in-depth interviews, watching actual demand-generating activities, and investigating the demand planning process, the literature review and a single case study analyse the underlying reasons for the demand for spare parts. This shows how causal-based forecasting interventions based on product-in-use data could be useful in the aftermarket. From this perspective, eight possible interventions have been presented as having a potential positive impact on the demand planning process. For the suggested causal-based demand planning, five categories of data types have been identified as important (operational data, fault codes, sensor data, install base, and item usage). This report findings add to current demand and supply chain planning research by linking literature-based causal-based methodologies to a contextual framework that includes required data types and item attributes. Other companies in the aftermarket industry may be able to use the eight different interventions. The created interventions match the context of phase-in and phase-out items since they are based on regression between demand and various types of product-in-use data (e.g., mileage, degradation, and fault codes). Low-frequency items were fitted with developed interventions based on condition-based management, which used data from on-board sensors and diagnostics to predict failure type and time. Early in the life cycle, when there is little or no past data, developed reliability-based therapies are appropriate. These interventions are based on the anticipated service or breakdown time, as well as the installed base. We've also shown how product-in-use data-based interventions affect various steps in the demand planning process, including not only forecasting but also the possibility of reducing demand plan uncertainty by moving part of the demand from forecast to dependent demand, which directly affects the demand plan [44].

Michael and Walter, 2017	Predictive diagnostics presents new service models to improve vehicle and machine availability, optimize maintenance intervals, and reduce vehicle and machine maintenance time and costs. The article provides an overview of predictive diagnostic principles and methodologies. System and component information, as well as existing and novel algorithms, as well as vehicle and environmental data, must all be used in predictive diagnostics. The goal of this service is to use state-based pro-files to predict upcoming component breakdowns throughout daily operations and to optimize the period inspection. The vehicle driver, automobile manufacturer, or fleet management will be able to schedule a maintenance window or an exchange of the affected component in advance using this information. As a result, an unforeseen failure might be turned into a planned maintenance event. Predictive diagnostics for the automotive industry applications asks for a holistic strategy that incorporates deep component and system knowledge, new Satterthwaite-Welch function methodologies, powerful infrastructure with easy functionality updates, and deep data analytics capacity. The entire benefits of predictive diagnostics are reduced expenses for unexpected breakdowns, improved periodic inspection, and lower operation costs with this technique. It may also assist the automobile manufacturer in improving customer satisfaction. Bosch offers concepts, methods, and solutions for creating automotive predictive diagnostics. The principle can be used to passenger cars, trucks, and off-highway vehicles. More and more components and systems are becoming "ready" for predictive diagnostics as a result of a progressive approach [45].
Gourav, 2019	Technical Data Management recommendations towards Marketing, Sales and After-Market. The names of the departments mentioned are listed in the order in which they completed a project. Because they are in direct contact with the client, these departments are the face of the industry. Because these divisions serve as a link between the industry and the market, they must be well-versed in the fundamentals of the Company's products, services, and unique selling factors in order to boost marketing effectiveness. This necessitates that marketing personnel keep tables and charts on hand that outline the technical specifications of the products. Similarly, salespeople must keep track of market trends based on consumer expectations and new market trends. After Sales is primarily concerned with the resolution of customer questions and complaints. In the ideal case, a company's growth is assessed by the effectiveness of its production, i.e. the marketability of its items. General assembly designs, specifications of the hill of material used to build the product, special components or materials used, and feasibility reports are all examples of technical data linked to products for these divisions. There are two types of data management: order-centric and data-centric.

	Order-centric data management involves creating a new folder for each order and storing related data in it so that it may be retrieved later. The second option is product-centric, which allows for the storage of product-specific data. Both strategies need a disciplined approach because little errors can lead to big miscommunications in the context of technical feasibility and can magnify future errors. As a result, it is advised that, first and foremost, sound knowledge and, second, a technical knowledge pool that is order or product centric be maintained [46].
Wayne, Shirley, Jaume and Syd, 2018	Data science and big data analytics are now being used in almost every facet of modern life, including online security, finance, insurance, advertising, medicine, streaming services, city/traffic planning, and a variety of other fields. Statistical analysis and pattern discovery can be used to generate unique and innovative insight whenever and wherever data is collected, usually with the goal of achieving a competitive edge. The automobile aftermarket is no different, with web-hosted catalogues gathering massive statistics on every element of buying car components online. These statistics contain a wealth of information regarding searches for and purchases of automobile parts – when, when, and what – as well as details about the parts themselves. The data can be used to derive patterns of purchasing behaviours, preferences, return rates, and product features. Rain Data Ltd and Newcastle University's School of Mathematics, Statistics and Physics, as well as the School of Computing, collaborated on the results presented below. Rain Data collaborates with MAM Software, which provided the data used in the following analysis. The types of analyses we have applied to transactional automotive datasets include: Determining the return rates of auto parts; Determining measurements of factory-fitted parts (standards of the original equipment manufacturer (OEM)) for the automotive aftermarket; Measuring and predicting when auto parts need to be replaced; Gaining insight from big data on electronic transactions about which combinations of cars, models, auto parts and suppliers account for the largest proportion of invoice entries; Tracking profit margins; Optimising pricing; Detecting seasonal trends in sales and returns [47].
Daniel, José and Maria, 2021	The meeting begins with a review of previous metrics in order to keep track of the quality of both the process and the planning outcomes. The cross-functional teams will then assess the potential demand. The disparities between the sales budget and the most recent forecasts are examined. Following that, the Planning team delivers an analysis of each plan's evaluation metrics. The sales and operations teams debate the implications of each strategy and agree on a course of action. The company's CEO attends the meetings and ensures that everyone is working toward a same goal.

	Following the definition of the direction, a breakdown of the plan is offered, with an emphasis on machine occupation and analysis of the most important orders, clients, or product families. Additional changes to the plan are addressed, and the action plan is consolidated by the Planning team. Among the many challenges, the necessity for a refined strategy arises when capacity is insufficient to meet demand satisfactorily. Further capacity adjustment procedures are defined in this scenario, or obligatory orders must be ensured for a subsequent iteration of the plan. Another countermeasure is for the sales team to agree on orders or items whose demand will be met with a delay or will not be met at all. When inventory levels are too low, a priority can be set for the products whose inventory levels are more critical to replenish. The model is then run with safety stocks that have been modified. The Planning team is in charge of running the model with the refined parameters and reporting back to the S&OP committee on the results. If the revisions are considerable, a final meeting will be required to discuss and approve the final plan. With this case, we hope to show some managerial implications for companies looking to improve their S&OP practices by implementing these recommendations. First, there must be the requisite digitalization to embrace an advanced multi-objective S&OP model to ensure that the decision-support system has the necessary resources to run it and that the information is of high quality and dependability. Second, the S&OP coordinator's function is important. This component is in charge of creating and pre-validating the various plans. Third, S&OP meetings' agendas must be adjusted to accommodate the discussion advocated in this report [48].
Gianfranco, Richárd, Krisztián and Marcello, 2021	The federation's DOS providers provide services and data that other nodes can use, as well as optional added value and sector-specific functions and data given by third parties. The platform's OpenAPI based set of functions (profile registration, circular entity management, material/product data publication, matchmaking and negotiation, and so on) ensures interoperability among nodes. Stakeholders will be able to publish their offer from a single node, and the federation would then make it available for searches, analytics, and other data discovery. Each Digi Prime service follows the twelve-factor paradigm for developing software as a service programs, and is packaged and delivered using Docker containerization technology. The platform offers three types of integration mechanisms, depending on the DOS's specific disclosing requirements and the pilot data confidentiality: fully integrated (deployment + circular data sharing), partially integrated (deployment on the DOS provider's premises but with circular entity data sharing with the platform), and standalone. Smart contracts, which govern who can access data and under what conditions, are inextricably linked to the concept of data sharing in DOS. Only particular business entities (organizations, businesses, etc.) will have access to specific data sets via a data channel. It is an agreement between the data

	owner and the permitted entities who have access to the data sets. The goal is to build trust among all parties involved [49].
Amie, Brook, Blair, Frederick, Timothy and Luke, 2021	This work presented a conceptual framework based on known modifications to visual attentional processing under complicated drug settings for quantifying gaze behaviour in order to determine impairment due to amphetamine use. However, this method could be a valuable and sensitive way to capture the psychotomimetic effect profile for a wide range of medication classes. Gaze behaviour is a broad term for the complicated oculomotor control that governs periods of saccades and fixations during continuous visual exploration in naturalistic environments. These systems prioritize attentional processes involved in visual information selection and processing in order to inform visually guided behaviour. We can begin to shift the detection of impairment before a potential mishap by adopting a more proactive technique of classifying driver status, rather than detecting someone who has arrived at a testing facility or after a driver has been engaged in a traffic collision [50].
John, Nikos, Angela, Ulf, Andrea, Antonella, Carlo, Dena and Marcello, 2021	Data Search services are critical for tracking and tracing the status of circular data items, as well as their lifespan inside the platform. Collecting and integrating all data pertaining to a circular data entity is a frequent CE process. In this situation, browsing all of the datasets of the various parties in the circular chain is required to find an entity's lifecycle. When dismantling a car, for example, the user might be interested in finding battery lifecycle data and shared datasheets by searching topic and serial number on all federation sector nodes [51].
Viktor, Alexander, Thomas and Mikael, 2021	This article has addressed the subject of how incumbent businesses employ dynamic capacities to shape markets in sustainability transitions, based on a comparative case analysis of the efforts of two heavy vehicle manufacturers to develop alternatives to typical diesel-fuelled trucks. Existing market positions of incumbent enterprises will be open for reinterpretation and renegotiation as a result of the system reconfigurations connected with sustainability transitions. This may present both challenges and possibilities for the incumbent, to which it must respond. Furthermore, the possibility of system reconfigurations allows for plenty of projection, interpretation, and strategic manoeuvring. This study demonstrates how incumbent enterprises can respond proactively to market shaping opportunities. It emphasizes the importance of deploying market-shaping powers to reform institutions. This is due to the fact that such deployment allows incumbents to claim genuine positions in future marketplaces.

	This study outlines a paradigm that shows crucial connections between individual businesses' market-shaping capacities and system-level market-shaping activities [52].
Danilo, Flavio, Eliana, Antonio, Tania, Elena, Marco and Davide, 2021	PREPIPE, a data-driven framework for doing predictive maintenance, was presented in this report as a case study for the automotive industry. They used a pipeline to anticipate the clogging condition of the oxygen sensor in the automotive industry, in particular. This report demonstrate how domain experts may use their approach to choose the appropriate subset of signals and features to forecast the status of the system under investigation. Signal and feature selection are critical. The domain specialists can better comprehend the crucial components of the clogging phenomena by finding the most important signals describing it thanks to the interpretable outputs of the signal and feature selection algorithm. The findings of the use case under consideration show that selecting the appropriate strategy is critical for ensuring accurate performance estimation of the deployed solution and the applicability of the proposed approach for dealing with time-dependent data [53].

3. COMPANY AND PROBLEM PRESENTATION

In this chapter it will be presented the company where this thesis took place as well as the problem presentation. It will also be added the presentation of the software used to treat the data that was collected during the internship.

3.1. Company Presentation

In 1926, in Vila Nova de Gaia, Salvador Fernandes Caetano was born, the founder of the Salvador Caetano Group. It was only in 1968 that the group started to take their first big steps in the automotive industry with the signing of the importation and distribution contract of the Toyota brand in Portugal. After this important mark, Salvador Caetano Group developed strong and deep roots that allowed to the business to expand to other areas and even to start some adventures abroad. Today the group counts with more than 100 companies established in Europe, South America and Africa in the following business areas: industry, distribution, and car sales and services.

One of the most recent acquisitions of Salvador Caetano Group is the ownership of the master franchisee of Midas Portugal. This acquisition closes the loop of the car sector to this group. Making it present in the sale of car, the first years of services with the OEM solution and then the following up of the costumer/car services with Midas being the aftermarket solution.

Midas is an International Group that started their history in 1956 with the first shop opening in the city of Macon, Georgia USA.

The concept of MIDAS fast fit rapidly made success and after one year of operations there were already 100 shops open to the public.

Incredible developments were made and in the 60's the concept expanded to other countries such as Canada, Australia and Mexico. In the 70's, Midas opened the first shop in Europe. In Europe the brand is represented by the group Mobivia, a group with more than 40 years of experience in equipment and vehicle maintenance.

Nowadays Midas counts with a presence in 5 continents with more than 2.200 shops in the world.

Midas started by selling exhaust systems and it was with this product that they conquered the aftermarket sector. Today the range of the product commercialized by Midas is extended to all the services listed below:

Electronic diagnosis; Car maintenance; Tyres; Batteries; Brakes; Air conditioning; Timing belt; Clutch; Own products and more.

All the products commercialized by MIDAS are manufactured under our mission of "taking care of all of our customers in a sustainable way". With a clear commitment, a wide range of services, an advanced technical knowledge, and the desire to take care of their costumers every day, MIDAS still continues to grow its presence throughout the world.

3.2. Problem Presentation

Climate-related measures keep changing, and mobility is one of the most affected sectors. In the last years we've encountered stricter regulations almost by the year, most of them being directly related to global warming. As a vast majority of the active population owns a vehicle for mobility and/or recreational use, on this thesis it was studied how the car parc evolution and change, particularly regarding the emissions restrictions, will affect the fast-fit sector.

The best way to describe the problem is to look at the way aftermarket is behaving and assess what might happen to it in the future. Thus, the industry of automobility is changing to be a cleaner and more sustainable way of travelling. For this reason, manufactures have been working on developing new technologies that help vehicles (and their production lines as well) produce less emissions as well as promote the use of recycled materials in the assembly of vehicles. In Portugal's case, we've been facing moderate financial benefits from part of the government for those who acquire and own greener vehicles: the internal combustion engine cars pay less taxes the less CO_2 emissions they produce, including importing fees, and hybrid and electric vehicles are even exempt from some of those taxes. All of this in order to make the Portuguese car parc less and less pollutant and meet the EU goals regarding the carbon footprint.

As it's known, in today's market there are solutions for customers who search beyond the conventional internal combustion engine and those range from electric vehicles to hydrogen vehicles. These ways of mobility use lower displacement engines and have regenerative systems in use and for these reasons they can expand the lifetime expectancy of their components. This will affect the rate of return of each car to the shop and this issue will grow over the next decade, threatening to reduce the invoice volume and profit margins of this sector because not only new technologies need less maintenance and services but also those standard services, that are effectively required, are of lower margins.

In this case new tools must be developed in order to maintain the sector alive and up to date to new vehicle's needs. Also, these cars with new technologies demand for more knowledge and more qualified labor from the shops. This means that those shops which apply these qualities, fair amounts of knowledge and more qualified labor, will have a higher running cost as they'll be required to have higher skilled people working than the average shop.

In conclusion, the sector needs to find ways to evolve proactively and be ready to accommodate the newer cars and motorbikes without compromise and to a standard that keeps the costumers feeling that they're not missing out by choosing our shops instead of going to the manufacturer option. It also must implement new management and data processing methodologies that keep the customers satisfied with the efficiency of all the services and returning to the shops, whilst maintaining the business profitable.

3.3. Data Software "R"

To treat the data collected we will use a software that can present such data in an easier from to read. The software selected was R Studio, wich is a free and open source software.

R is both a work environment and a programming language. Code that is descriptive is used to carry out commands. The plots are directly viewed in their own window, and the results are presented as text. The statistical program S-plus's clone is R.

The object-oriented programming language S-plus was created in 1988 by AT&T Bell Laboratories. Data manipulation, plotting, and statistical data analysis are all done with S-plus.

R is a robust statistical program. R has a high learning curve. R is not the type of statistical software that you can use by simply clicking a couple times in the options.

This is a didactic program and to utilize it, you must comprehend the statistical procedure that you are attempting to apply. Once you have grasped R, it is also incredibly effective and simple to use. You will have the ability to design your own tools and work with extremely complex data analytics.

One of R's key advantages is its ability to combine a programming language with the capability to create excellent charts, which is significantly greater than that of other software on the market. Using established functions, common charts are quickly generated.

Numerous options are also included in these functions, such as those for adding titles, captions, and colours. However, more complex charts can also be made to show complex data, including density curves, volumes with a 3D effect, and contour lines. You can also include mathematical formulas. Multiple plots can be arranged or overlaid in the same window while using a variety of colour schemes. Also, in R we are able to create forecasts with the data collected [54].

4. THESIS DEVELOPMENT AND RESULTS

Chapter 4 will present how the data was collected. We will then find the structuration and presentation of such data in a graphic/table overview. A SWOT analysis of the sector will also be displayed in this chapter.

4.1. Data Collection and Structuration

In this thesis, the data collected needs to ensure the distinction on the type of vehicle, the type of service performed, the labor used and the location of the shop.

The data retrieved is from eight aftermarket shops in Portugal. All shops differ on location, and we believe that this will result in a different car parc demonstration. For this reason, each shop was selected with the purpose of enriching our study.

It must be referred that the data was collected by shop in different periods. The data is from eight shops that opened doors to public throughout 2021. For this reason, some of the shops opened in April 2021 and others in November 2021. In some aspects the smaller data base does not influences the output of the results but, in other cases, we need to be careful to compare the comparable.

From ten aftermarket shops that Midas Portugal held in 2021, we have selected eight to perform our analysis. We will now list them here by theoretical time of opening, being that some of the shops suffered some delays on their openings due to operating licenses issues.

Marques's shop which is in Porto city centre. This is the second oldest aftermarket shop in Midas Portugal where we have three technicians operating. The data from this shop was collected between June 2021 and March 2023 giving us a sample of 22 months to analyse.

Following we have Carregado shop. This shop is located outside of Lisbon, Portugal capital, and it is the oldest aftermarket shop of Midas Portugal. This shop counts with three technicians and opened in April 2021. Although, the data collected for this thesis is from May 2021 till March 2023 (23 months).

Next, we have Aveiro shop. This shop is located south of Porto but it still belongs to the northern region of Portugal. This shop was selected for this study because it is far from areas with the highest buying power, Lisbon and Porto, and it would be interesting to analyse their car parc evolution regarding new ways of mobility and still fill out our national sample. The data for this shop was collected between October 2021 and March 2023 (18 months). This shop also has three technicians working.

Porto Zi shop is the following shop to be presented. This is one of the biggest shops from Midas Portugal. It is located in the industrial zone of Porto and it counts with four technicians. This shop works mostly with fleet and pro costumers and can give us a perfect understanding of the national companies fleet and wich type of vehicles still endure. Porto Zi data collected expand from October 2021 and March 2023 (18 months).

Going straight to the south of Portugal. In Faro we have Loulé's shop. This is the only shop from Midas Portugal in Faro region and will contribute to have a national understanding of the car parc evolution. This shop is integrated in a shopping facility. The same shop has three technicians, and it is one of the smallest shops, in square meters, from Midas Portugal. This shop opened in February 2022 and the data was collected from March 2022 till March 2023 (12 months).

Odivelas shop was also consider in this study, since it was the shops that was the nearest to Lisbon making it the only shop that would be near the capital of Portugal. Odivelas has three technicians working full time. This shop opened to the public in October 2021 and the data was collected between November 2021 and March 2023 (17 months).

Since Midas Portugal has a greater presence in the north of Portugal. We have decided to include two more shops from the north. One being in the interior region and other being in the surroundings of Porto.

Vila Real is the shop selected from the interior region. This shop adds to the study a view from an area with less purchasing power and people with higher millage to cover in a daily basis. This shop also has three technicians and it opened doors to public in November 2021. The data was collected from December 2021 till March 2023 (16 months).

Vila do Conde is the shop from the surrounding of Porto. This shop was selected because is one of the highest investment shops from Midas group and one of the best prepared to receive new types of mobility vehicles. It counts with three technicians and the data was collected from November 2021 till March 2023 (17 months).

Figure 3 displays the shops presented above on the map of Portugal.

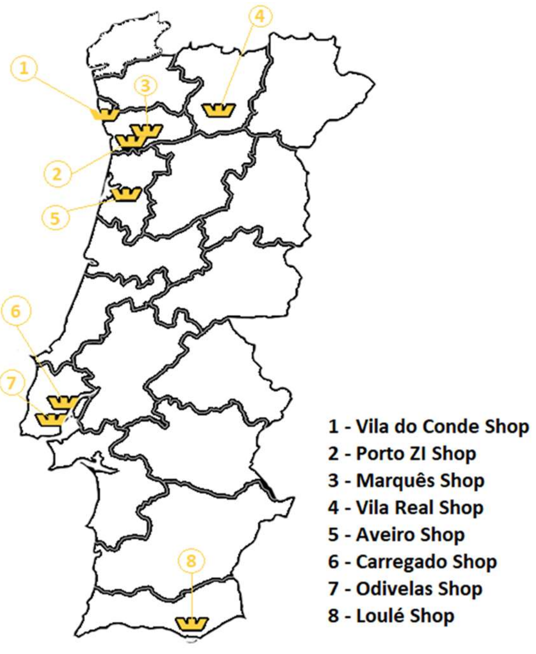


Figure 3 - Midas PT Shops Location

For the study, a set of data was considered. This data was inserted by each shop in their eMidas. eMidas is the CRM used by Midas shops that collects all the info from the services performed in the workshops as well as the costumer information. Then, we retrieved all the data from each shop and worked on it to correspond to our needs.

4.2. Ideas SWOT Analysis

On this chapter we presented, in Table 6, a SWOT analysis of the aftermarket sector. After consulting several documents and speaking with colleagues in the sector, we carried out the following SWOT analysis. With this analysis we can get a better undertanding of this sector.

Table 6 - SWOT Analysis

Strength:	**Weaknesses:**
➢ Evolution of the sector ➢ Lower emissions of CO_2 ➢ Renovation of the car parc	➢ Shops not technical prepared ➢ Reduction of the re-entries in each costumer ➢ OEM more competitive when compared to the aftermarket sector.
Opportunities:	**Threats:**
➢ New and more specialized teams ➢ New ways of business ➢ New management models	➢ Higher hiring difficulties ➢ Reduction of the gross margin ➢ Higher fixed costs of operations (Labor)

4.3. Critical Analysis of the Results

With the collected data we can now make an analysis of the actual situation of the national car parc. With the help of "R" software we were able to treat and present the data collected in the following graphics from. These graphics will show us the occupation of each shop by service performed.

In the time span of data collected we can calculate an average entry of 4480 vehicles by shop as shown in Figure 4. And the graphic below show the occupation of each shop in labor hours by services made to costumer cars.

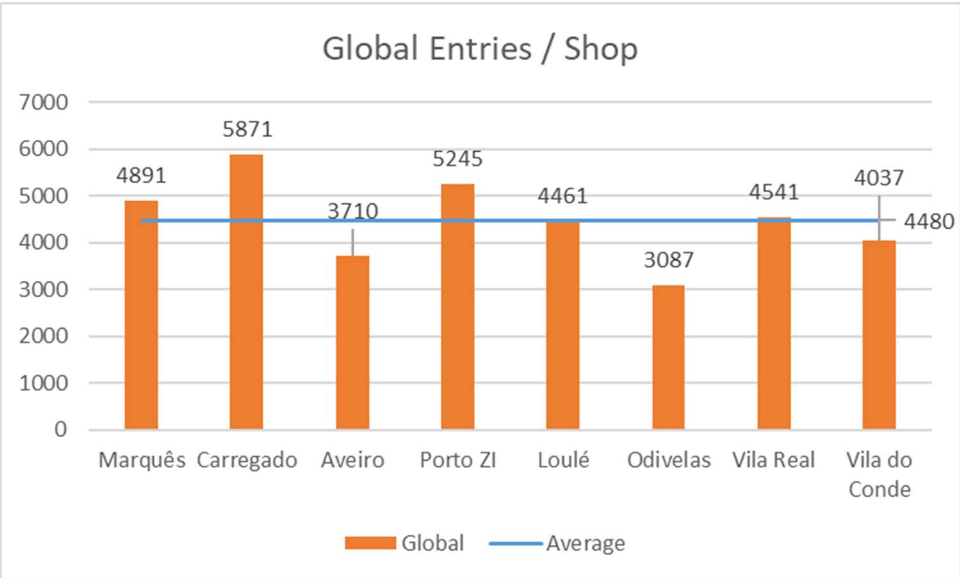


Figure 4 - Global Entries by Shop

Our focus now is to look to the labor by shop graphics, study them and define the areas of main occupation for the actual fleet of cars that visit our shops. To follow a road, we will set to identify the three main areas of occupation of each shop.

The graphics used to study the labor occupation are boxplots. These were invented by John W. Tukey that was an American mathematician and statistician. This type of graphics will display significant data that has to do with the occupation hours in labor for each shop. We will be able to retrieve the minimal (Min) and maximum value (Max) of labor registered and the Q1, Q2, Q3 and IQR values referring to the median.

Q1 – first quartile, the 25th percentile. It means that 25% of data falls below this value (Q1).

Q2 – is the median.

Q3 – third quartile, the 75th percentile. It means that 25% of data is greater than this value and 75% falls below Q3.

IQR – is the interquartile range, $IQR = Q3 - Q1$

In the graphics the LH means labor hours and the first two letters stand for: OR - Official Revision; HE – Heat Engine; BS – Brake System; OS – Other Services; TS – Tire System; AC – Air Conditioning.

Figure 5 shows a perspective of the occupation of Marquês shop. The data of Marquês shop was collected from June 2021 till March 2023 (22 months).

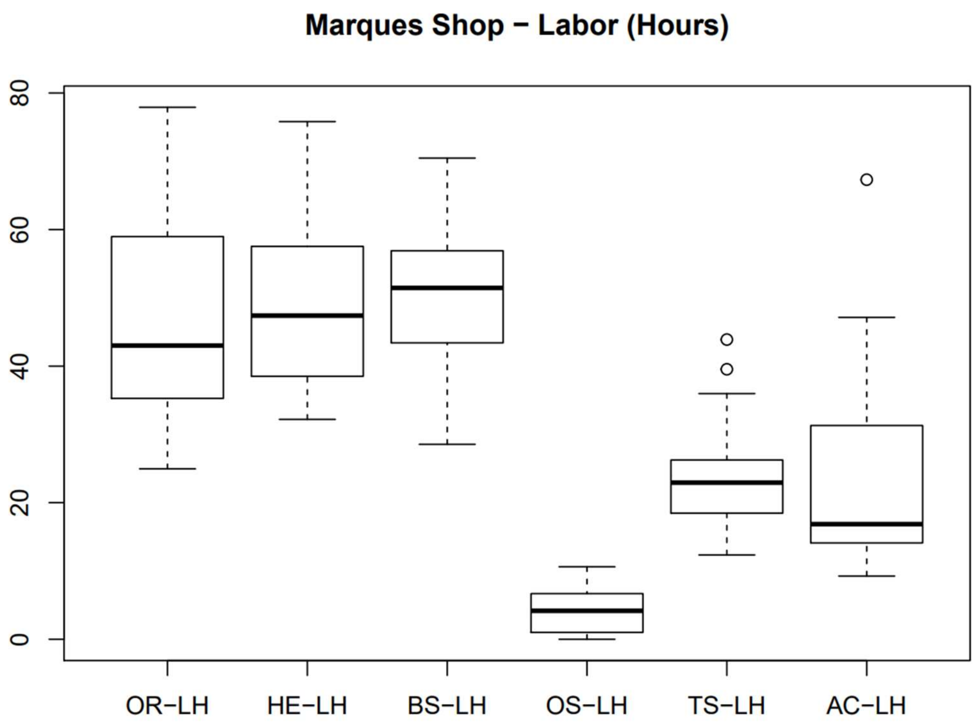


Figure 5 - Labor Hours Marquês

The results are presented in Table 7:

Table 7 - Boxplot results Marquês Shop

Labor Hours	Min (H)	Max (H)	Q1 (H)	Q2 (H)	Q3 (H)	IQR (H)
Official Revision	25	78	35	44	58	23
Heat Engine	35	75	40	48	56	16
Brake System	30	70	46	52	55	9
Other Services	0	10	2	6	8	7
Tire System	15	36	18	23	25	7
Air Conditioning	8	50	16	18	30	14

The graphic was analysed, and the results presented in the above table show that:

- From the official revision (OR-LH) plot we can conclude that the median is closer to the Q1 value meaning that the data is right skewed.
- The heat engine (HE-LH), we conclude that the distribution is right skewed.
- The distribution of the labor hours in the Brake System (BS-LH) is roughly symmetrically distributed (it is slightly left skewed).
- Other Services (OS-LH) values show that the distribution is right skewed.
- In Tire Systems (TS-LH) distribution we can observe outliers right skewed (circles extended beyond the upper whisker). An outlier is a single data point that goes far outside the average value of a group of statistics.
- Air Conditioning (AC-LH) values show that the data is right skewed.

From this graphic we are able to conclude that the services with the higher demand of labor in Marquês shop are official revisions, heat engine services and brake services. The data collected is mostly right skewed. This means that the mean is greater than the median. This occurs because the data is pulling the mean towards lower values while the median remains closer to the middle of the data.

In Figure 6 we have the labor from Carregado shop. The data of Carregado shop was collected from May 2021 till March 2023 (23 months).

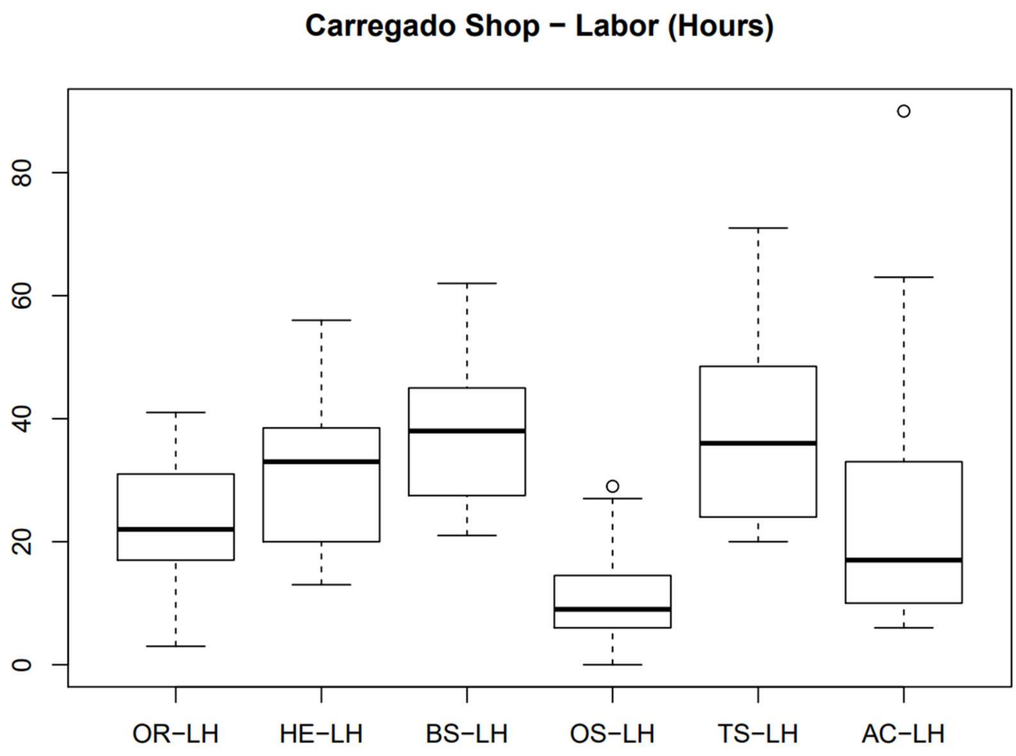


Figure 6 - Labor Hours Carregado

The results are presented in Table 8:

Table 8 - Boxplot results Carregado Shop

Labor Hours	Min (H)	Max (H)	Q1 (H)	Q2 (H)	Q3 (H)	IQR (H)
Official Revision (OR)	2	42	18	22	35	17
Heat Engine (HE)	16	60	20	36	38	18
Brake System (BS)	20	60	24	40	44	20
Other Services (OS)	0	24	5	7	15	10
Tire System (TS)	20	70	22	37	52	30
Air Conditioning (AC)	5	62	10	15	35	25

The graphic was analysed, and the results presented in the above table show that:

- In the official revision we can conclude that the data collected is roughly symmetrical (slightly left skewed).
- For the Heat engine results, the data collected is right skewed.
- The Brake system, the data collected is right skewed.
- Regarding Other services we can see some outliers right skewed.
- Tire system shows us that the data collected is right skewed.
- Air conditioning, the data collected is right skewed. We can also see some outliers right skewed.

In this case we can conclude that the main areas of services are the heat engine services, brake services and tire system. We can also understand that the data collected is mostly right skewed, meaning that the mean is greater than the median and that it overestimates the most common values in a right skewed distribution. Skewness represents better the extreme sets of data presented in a distribution and tells us if the average value presented is an accurate value for the same distribution.

Figure 7 shows the data from Aveiro shop. The data of Aveiro shop was collected from October 2021 till March 2023 (18 months).

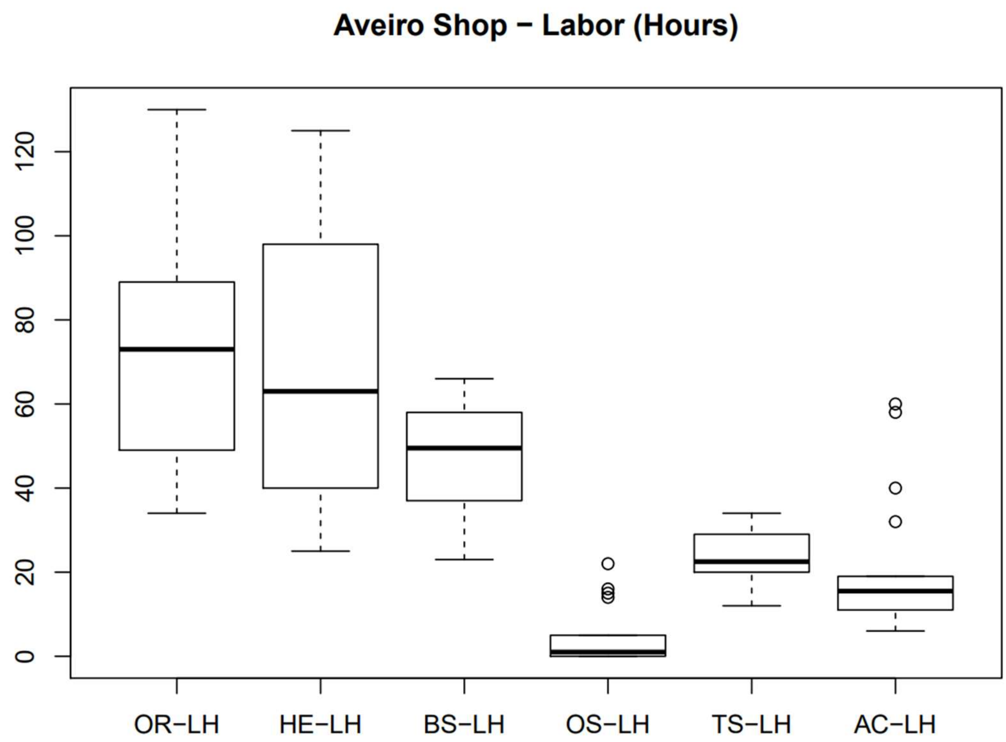


Figure 7 - Labor Hours Aveiro

The results are shown in Table 9:

Table 9 - Boxplot results Aveiro Shop

Labor Hours	Min (H)	Max (H)	Q1 (H)	Q2 (H)	Q3 (H)	IQR (H)
Official Revision (OR)	35	130	50	74	88	52
Heat Engine (HE)	25	126	40	64	98	58
Brake System (BS)	22	70	38	50	60	22
Other Services (OS)	0	6	0	1	6	6
Tire System (TS)	16	36	20	22	28	8
Air Conditioning (AC)	6	18	10	15	18	8

The graphic was analysed, and the results presented in the above table show that:

- In the official revision, the data collected is right skewed.
- Heat engine show us that the data collected is right skewed.
- Brake system values indicate that the data collected is left skewed.
- For other services, the data collected is right skewed.
- In Tire system, the data collected is right skewed.
- For air conditioning, we can see some outliers right skewed.

In Aveiro shop the top three highest demands are the official revision, heat engine services and brake services. The data in this shop is also mostly right skewed. Therefore, we observe another case where the median is closer to lower values than the mean. In these cases, the mean overestimates the most common values of the distribution.

Figure 8 shows the data collected form Porto ZI shop. The data of Porto ZI shop was collected from October 2021 till March 2023 (18 months).

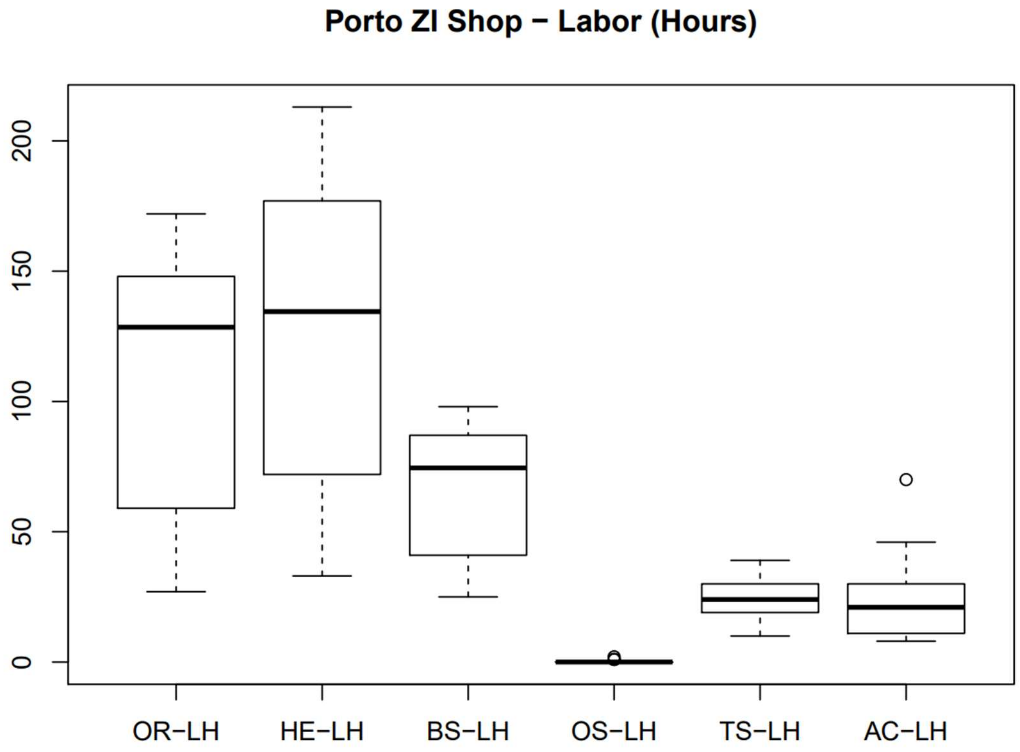


Figure 8 - Labor Hours Porto ZI

The results are presented in Table 10:

Table 10 - Boxplot results Porto Zi Shop

Labor Hours	Min (H)	Max (H)	Q1 (H)	Q2 (H)	Q3 (H)	IQR (H)
Official Revision (OR)	30	175	60	130	150	90
Heat Engine (HE)	35	220	75	135	180	105
Brake System (BS)	25	100	40	78	90	50
Other Services (OS)	0	0	0	0	0	0
Tire System (TS)	12	40	20	25	32	12
Air Conditioning (AC)	10	42	12	22	32	20

The graphic was analysed, and the results presented in the above table show that:

- official revision: The data collected is left skewed.
- Heat engine: The data collected is left skewed.
- Brake system: The data collected is left skewed.
- Other services: right skewed
- Tire system: The data collected is roughly symmetrical (slightly left skewed).
- Air conditioning: The data collected, and some outliers, are right skewed.

From the data collected in Porto ZI shop we can also conclude that the highest demand is in the official revisions, heat engine services and brake services. In this shop most of the labor hour data collected is left skewed. This means that the median is greater than the mean resulting in a underestimate of the most common values of the distribution.

Figure 9 shows the data collected from Loulé shop. The data of Loulé shop was collected from March 2022 till March 2023 (12 months).

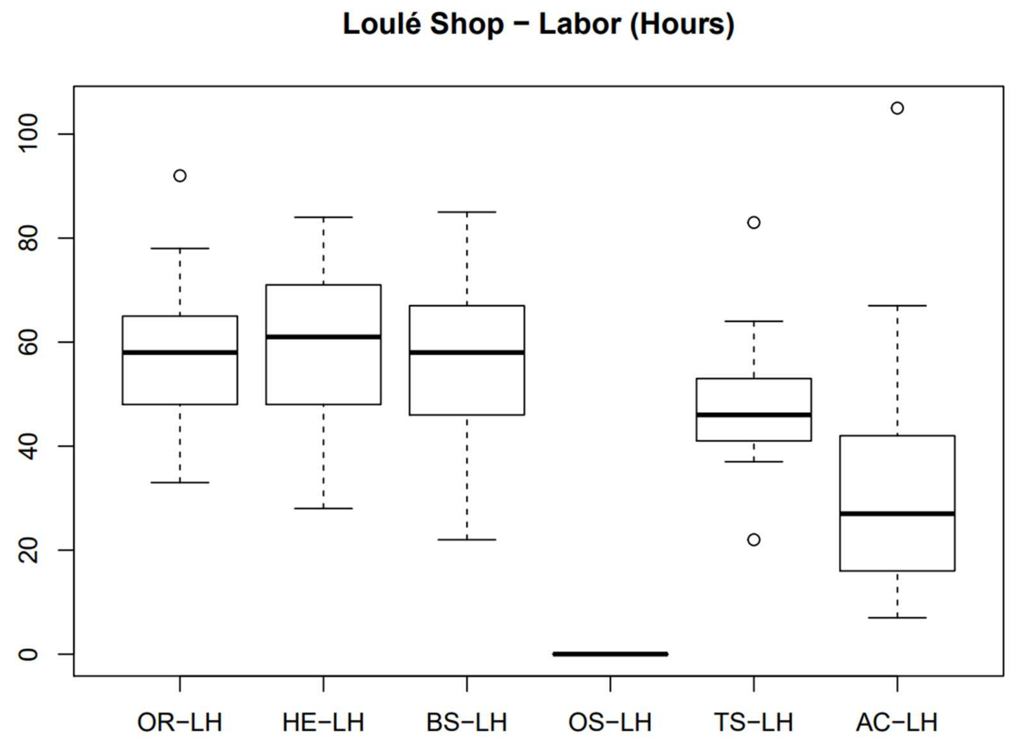


Figure 9 - Labor Hours Loulé

The results are presented in Table 11:

Table 11 - Boxplot results Loulé Shop

Labor Hours	Min (H)	Max (H)	Q1 (H)	Q2 (H)	Q3 (H)	IQR (H)
Official Revision (OR)	32	78	48	58	64	16
Heat Engine (HE)	28	86	48	62	70	22
Brake System (BS)	22	88	46	58	66	20
Other Services (OS)	0	0	0	0	0	0
Tire System (TS)	38	56	42	46	55	13
Air Conditioning (AC)	10	66	18	28	42	24

The graphic was analysed, and the results presented in the above table show that:

- Official revision: The data collected is right skewed.
- Heat engine: The data collected is left skewed.
- Brake system: The data collected is left skewed.
- Other services: No data.
- Tire system: The data collected is right skewed. There are also some outliers.
- Air conditioning: The data collected is right skewed.

From the data analysed we can conclude that in Loulé Shop the highest demand is also in the official revisions, heat engine services and brake services. In this shop the data collected is half right skewed and the other half is left skewed.

Figure 10 shows the data collected from Odivelas shop. The data of Odivelas shop was collected from November 2021 till March 2023 (17 months).

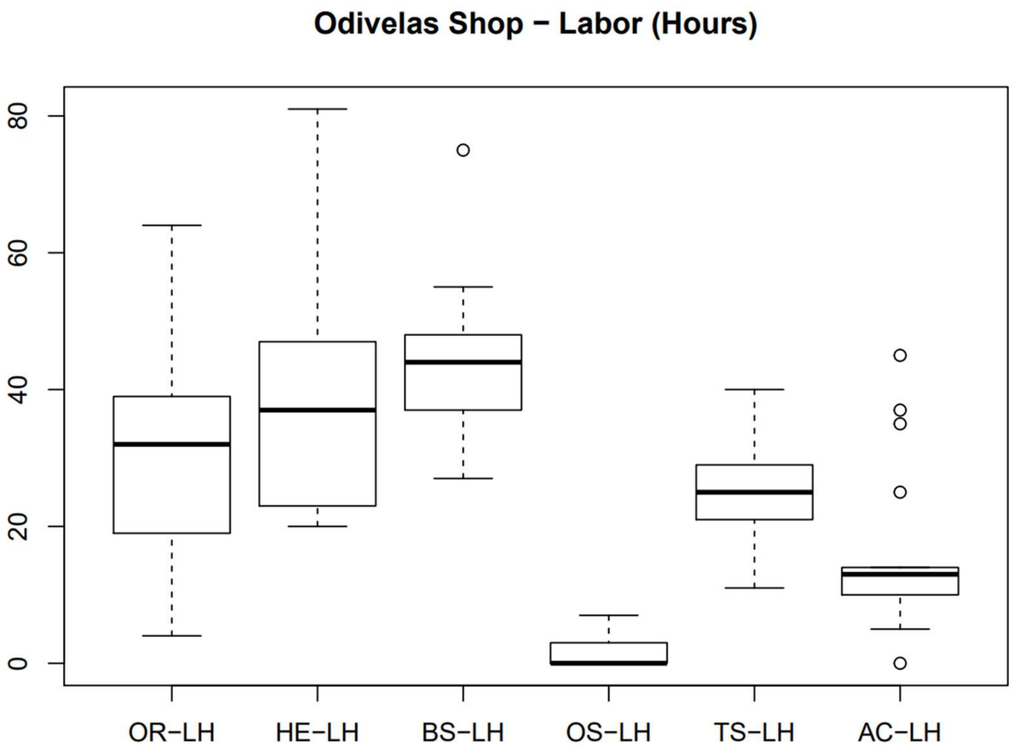


Figure 10 - Labor Hours Odivelas

The results are presented in Table 12:

Table 12 - Boxplot results Odivelas Shop

Labor Hours	Min (H)	Max (H)	Q1 (H)	Q2 (H)	Q3 (H)	IQR (H)
Official Revision (OR)	6	62	18	34	38	20
Heat Engine (HE)	20	80	24	38	46	22
Brake System (BS)	30	76	38	42	48	10
Other Services (OS)	0	5	0	0	2	0
Tire System (TS)	12	42	22	26	30	8
Air Conditioning (AC)	7	44	10	14	15	5

The graphic was analysed, and the results presented in the above table show that:

- Official revision: The data collected is right skewed.
- Heat engine: The data collected is right skewed.
- Brake system: The data collected is right skewed.
- Other services: The data collected is right skewed.
- Tire system: The data collected is roughly symmetrical (slightly left skewed).
- Air conditioning: The data collected is right skewed as well as the outliers.

From Odivelas shop we can conclude that the highest demand is in heat engine services, brake services and tire system. The data collected is mostly right skewed, meaning that the mean is greater than the median and that it overestimates the most common values in a right skewed distribution.

Figure 11 shows the data collected from Vila Real shop. The data of Vila Real shop was collected from December 2021 till March 2023 (16 months).

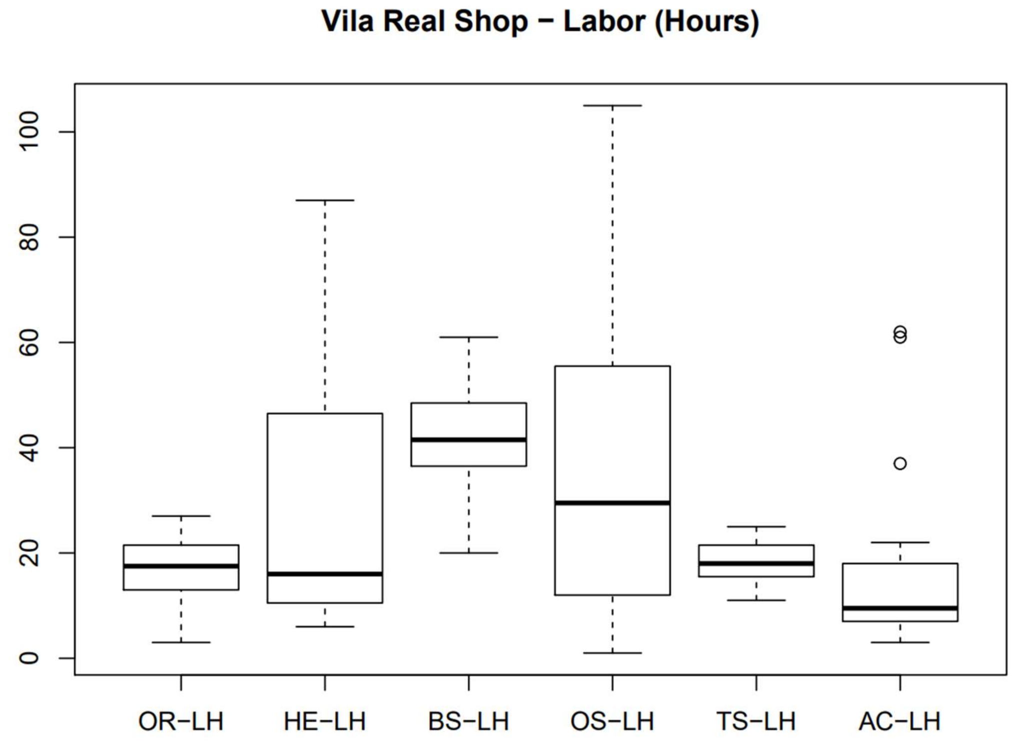


Figure 11 - Labor Hours Vila Real

The results are presented in Table 13:

Table 13 - Boxplot results Vila Real Shop

Labor Hours	Min (H)	Max (H)	Q1 (H)	Q2 (H)	Q3 (H)	IQR (H)
Official Revision (OR)	2	26	14	18	22	8
Heat Engine (HE)	8	86	12	16	44	32
Brake System (BS)	22	62	38	42	46	8
Other Services (OS)	1	105	13	30	56	43
Tire System (TS)	12	24	16	18	22	6
Air Conditioning (AC)	2	22	8	10	18	10

The graphic was analysed, and the results presented in the above table show that:

- Official revision: The data collected is left skewed.
- Heat engine: The data collected is right skewed.
- Brake system: The data collected is left skewed.
- Other services: The data collected is right skewed.
- Tire system: The data collected is roughly symmetrical (slightly right skewed).
- Air conditioning: The data collected is right skewed. Some, right skewed, outliers are also observed.

In Vila Real shop the highest demand is set in heat engine services, brake services and tyre system. The data collected is mostly right skewed meaning that the mean is greater than the median. So, for services where we have a right skewed distribution we cannot look to the average value presented because this value is overestimated when compared with the distribution.

Figure 12 shows the data collected from Vila do Conde shop. The data of Vila do Conde shop was collected from November 2021 till March 2023 (17 months).

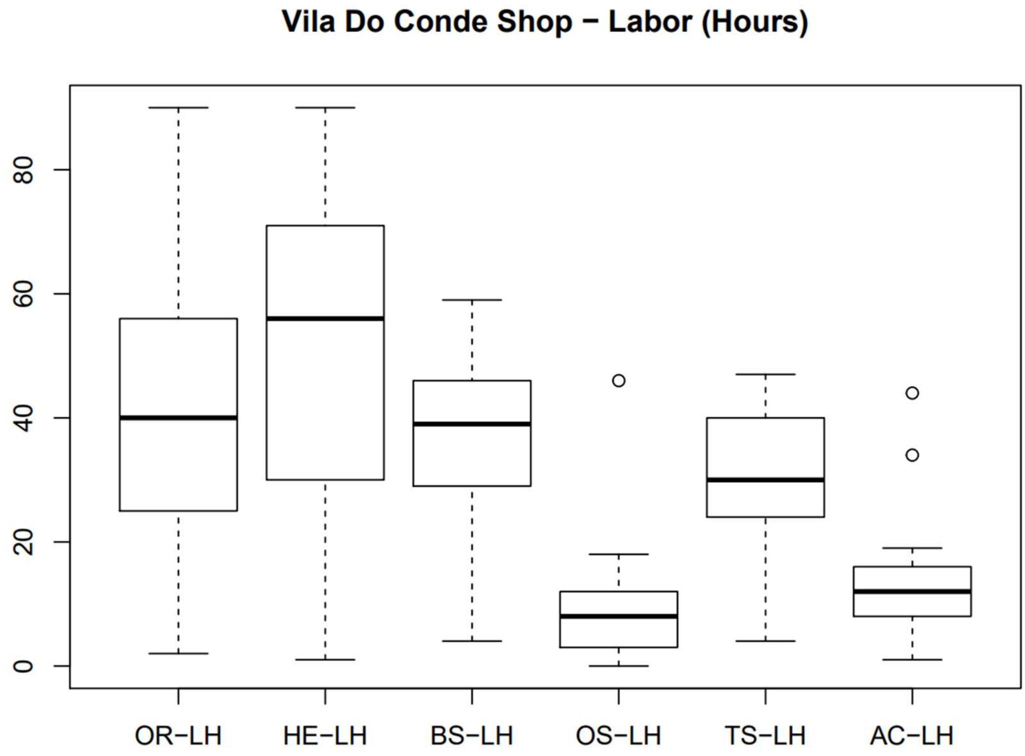


Figure 12 – Labor Hours Vila do Conde

The results are presented in Table 14:

Table 14 – Boxplot results Vila do Conde Shop

Labor Hours	Min (H)	Max (H)	Q1 (H)	Q2 (H)	Q3 (H)	IQR (H)
Official Revision (OR)	2	90	24	40	56	32
Heat Engine (HE)	1	90	30	56	70	40
Brake System (BS)	4	60	28	39	46	18
Other Services (OS)	0	18	3	8	12	9
Tire System (TS)	4	48	23	30	40	17
Air Conditioning (AC)	1	19	8	12	15	12

The graphic was analysed, and the results presented in the above table show that:

- Official revision: The data collected is right skewed.
- Heat engine: The data collected is left skewed.
- Brake system: The data collected is left skewed.
- Other services: The data collected is right skewed.
- Tire system: The data collected is left skewed.
- Air conditioning: The data collected is right skewed.

From Vila do Conde Shop the highest demand is concentred in the official revision, heat engine services and brake services. We can now understand that the data collected by service is even, being that for 50% of the services the data is right skewed, and for that reason the mean is greater than the median and it overestimates the most common values in a right skewed distribution. But, for the other 50% the data is left skewed meaning that the median is greater than the mean and, in these services, the most common values are being underestimated in the distribution.

With all the data that has collected in the last two years we were able to build the boxplot graphics that we have analysed. With this information we can reach to an agreement that main areas of occupation/income of these aftermarket shops are the official revision, the heat engine related work and the services made in the brake system of the vehicles.

The shops that didn’t present the same scenario are Carregado, Odivelas and Vila Real. The main reason that justifies the result obtained is that these shops have an older car parc when compared to the rest of the shops. The official revision is set to be performed/sold to newer cars because the main goal of this service is to preserve the official manufacturer warranty. So, in older cars this type of product isn’t so attractive to the costumer, especially when it has an higher price tag, hence the result from Carregado, Odivelas and Vila Real.

So, from the tree principal areas of activity in a Midas shop we will try to obtain a forecast for one of them. The goal is to predict the occupation of each shop in the next five months, in labor hours, related to official revision services.

The study of the time series for the management and optimization of resources in the technical assistance, maintenance, and automobile repair sector is an important and even fundamental point for the necessary efficiency and forecasting in order to better adjust resources with needs, which can translate into a maximizing turnover and potentially profit. In this context, it was considered to promote the outline of a statistical study, based on real data, which would allow showing some of the essential steps to be developed for the construction of a statistical model for the development of the respective experimental analytical model.

The study focused, above all, on the set of data that refers to the volume of work recorded over time, for a period corresponding to 23 months (or less).

It is recognized that the available data period is reduced, making various tests and studies impossible, such as: temporal decomposition that would allow the series to be decomposed into different components, trends, seasonality and residuals and thus analyse the amplitude of this seasonality over time; the seasonality test that would show more clearly, analytically and graphically the existence of a pattern over time; the Wald-Wolfowitz tenancy test; smoothing methods; between others.

Taking into account the limitation already identified previously (the sample size), the primary analysis method consists of the visual interpretation of the time series (presented in the next figures).

However, the possible conclusions to be drawn from this analysis are limited and may even lead to diagnoses and, consequently, decisions that are inappropriate or out of touch with reality.

Once again, with the help of the “R” software we were able to perform the forecast for each shop and display on a graphic the evolution of this service in each shop. Also, we present the result achieved with more detail in table Table 15, Table 16, Table 17Table 18, Table 19, Table 20, Table 21 and Table 22 presented below. The function used to perform the forecast was the function Autoregressive Integrated Moving Average (ARIMA).

ARIMA models include an explicit statistical model for the irregular component of a time series, that allows for non-zero autocorrelations in the irregular component.

ARIMA models are defined for stationary time series. Therefore, if you start off with a non-stationary time series, you will first need to ‘difference’ the time series until you obtain a stationary time series. If you have to difference the time series “d” times to obtain a stationary series, then you have an ARIMA(p,d,q) model, where d is the order of differencing used. You can difference a time series using the “diff()” function in R.

If you need to difference your original time series data (d) times in order to obtain a stationary time series, this means that you can use an ARIMA(p,d,q) model for your time series, where d is the order of differencing used.

It was possible to apply the Dickey-Fuller stationarity test to check whether the series presents a linear or stationary trend over time. In this case, the null hypothesis of the test is “the time series is non-stationary”. Therefore, for a p-value higher than the recommended significance level of 0.05, the null hypothesis is rejected, and the data is considered stationary.

As an example shown in Figure 13, after testing in R, the data concerning the labor hours for the official revision in the Carregado Shop we obtained the following:

```
          Augmented Dickey-Fuller Test

data:  coluna_dados
Dickey-Fuller = -3.4148, Lag order = 2,
p-value = 0.07572
alternative hypothesis: stationary
```

Figure 13 - Dickey-Fuller Test in Carregado Shop Official Revision Labor Data

Although the p-value is very close to 0.05, it is slightly higher, which for this set of data would be a statistical indicator that the series is stationary, therefore without a trend.

The same procedure was made for the other 7 shops, relating the official revision, and the same results were obtained, all the time series are stationary.

In a future study, with a greater volume of data, it is possible to study whether there is seasonality over time. The number of data collected does not allow us to correctly verify whether there is seasonality.

If your time series is stationary, or if you have transformed it to a stationary time series by differencing d times, the next step is to select the appropriate ARIMA model, which means finding the values of most appropriate values of p and q for an ARIMA(p,d,q) model. To do this, you usually need to examine the correlogram and partial correlogram of the stationary time series.

To plot a correlogram and partial correlogram, we can use the "acf()" and "pacf()" functions in R, respectively. To get the actual values of the autocorrelations and partial autocorrelations, we set "plot=FALSE" in the "acf()" and "pacf()" functions.

As an example, considering again the data relating to the official revision at the Carregado shop, the following graphs, Figure 14, were obtained resorting to the ARIMA method in R:

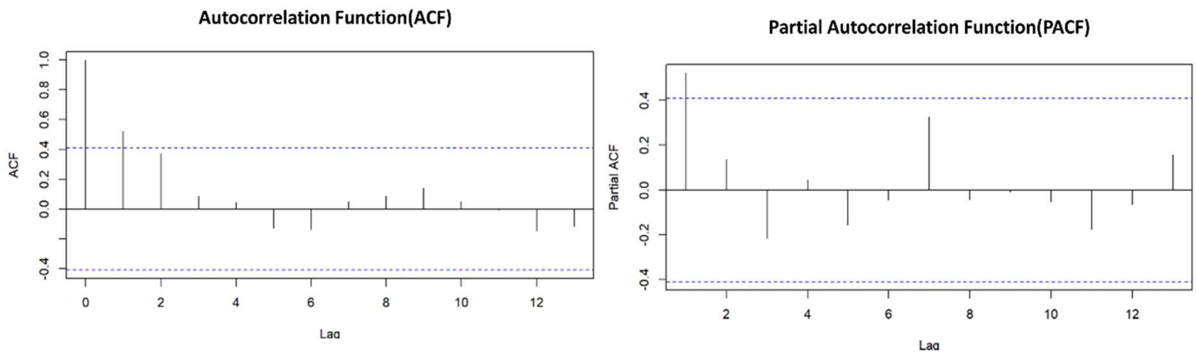


Figure 14 - ACF and PACF results for Carregado Shop

According to the observation of the two graphs, the model suggests implementing an autoregressive model without a moving average component, an ARIMA(2,d,0) type model. Applying the residual test to the model we obtain a p-value higher than the significance level, usually p-value=0.05, which is an indicator that the ARIMA model (2,1,0) may be statistically suitable for making predictions.

As mentioned previously, the amount of data available for analysis is too short to make sense to tune the ARIMA model parameters. Therefore, we decided to use the auto.arima() function to make a five months forecast for the labor hours of the official revision for all 8 shops.

It should also be noted that for longer period forecasts there is a significant decrease in variation which translates into greater uncertainty, as the width of the confidence intervals grows very abruptly, which is why a shorter period of just 5 periods was chosen.

The goal of the auto.arima() function is to automatically generate the optimal parameter values (p,d, and q), and give accurate forecast results.

Figure 15 presents Marquês shop forecasts. The data of Marquês shop was collected from June 2021 till March 2023.

The forecasts from June 2023 to August 2023 are plotted as a blue line, the 80% prediction interval as a dark grey shaded area, and the 95% prediction interval as a light grey shaded area.

For example, the forecasted labor hours for August 2023 is 47 hours, with a 95% prediction interval of (18.14, 76.01).

The Arima function gives us a forecast of the number of hours predicted to be necessary to execute the official revision of vehicles for five months, from April 2023 to August 2023. As well as 80% and 95% prediction intervals for those predictions.

The number of labor hours necessary for the official revision in March 2023 was 40 hours (the last observed value in our time series), and the ARIMA model gives the forecasted number of hours for the next five months as 47 hours as shown in Table 15.

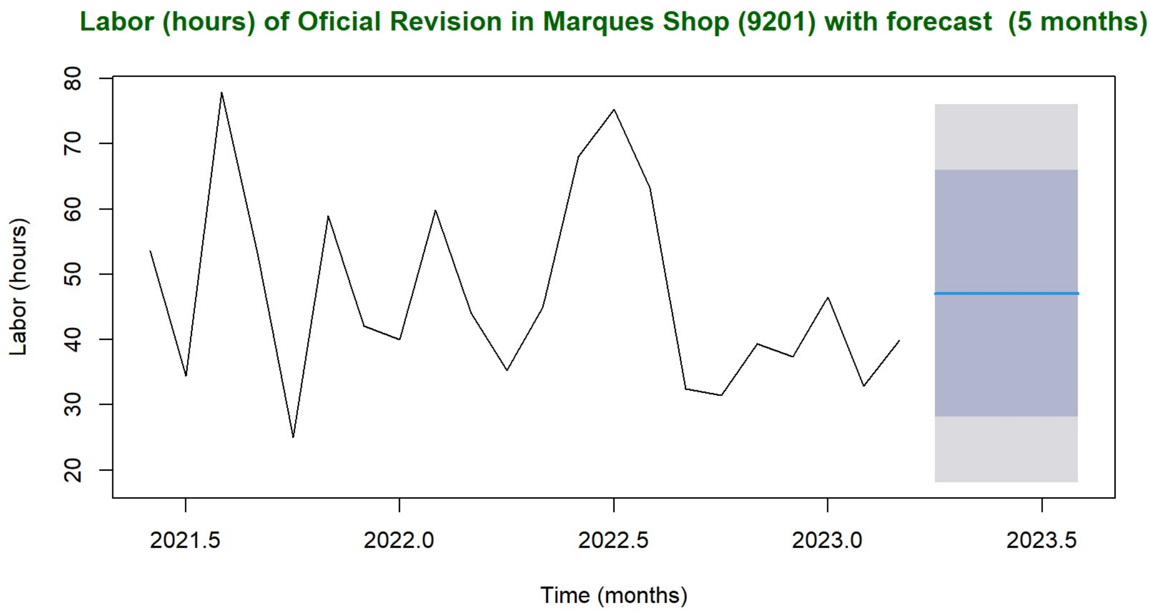


Figure 15 - Labor Forecast Marquês Shop

The forecast performed by R is stable for the following months. Giving a perspective of similar occupation in each following month. Table 15 shows the occupation in labor hours for each month forecasted. Point forecast column represents the blue line forecasted in Figure 15. Lo 80 and Hi 80 are the minimal and maximum value for the forecast with 80% precision and the Lo 95 and Hi 95 are the minimal and maximum value for the forecast with 95% precision.

In this case the number of hours of occupation don't surpass higher values than in the past data as shown in Figure 15.

Table 15 - Labor Forecast Marquês Shop

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Apr 2023	47.07449	28.15744	65.99154	18.14335	76.00562
May 2023	47.07449	28.15744	65.99154	18.14335	76.00562
Jun 2023	47.07449	28.15744	65.99154	18.14335	76.00562
Jul 2023	47.07449	28.15744	65.99154	18.14335	76.00562
Aug 2023	47.07449	28.15744	65.99154	18.14335	76.00562

In Figure 16 it is presented Carregado shop forecast for five months. The data of Carregado shop was collected from May 2021 till March 2023.

The number of labor hours necessary for the official revision in March 2023 was 41 hours (the last observed value in our time series), and the ARIMA model gives the forecasted number of hours for the next five months as 41 hours as shown in Table 16.

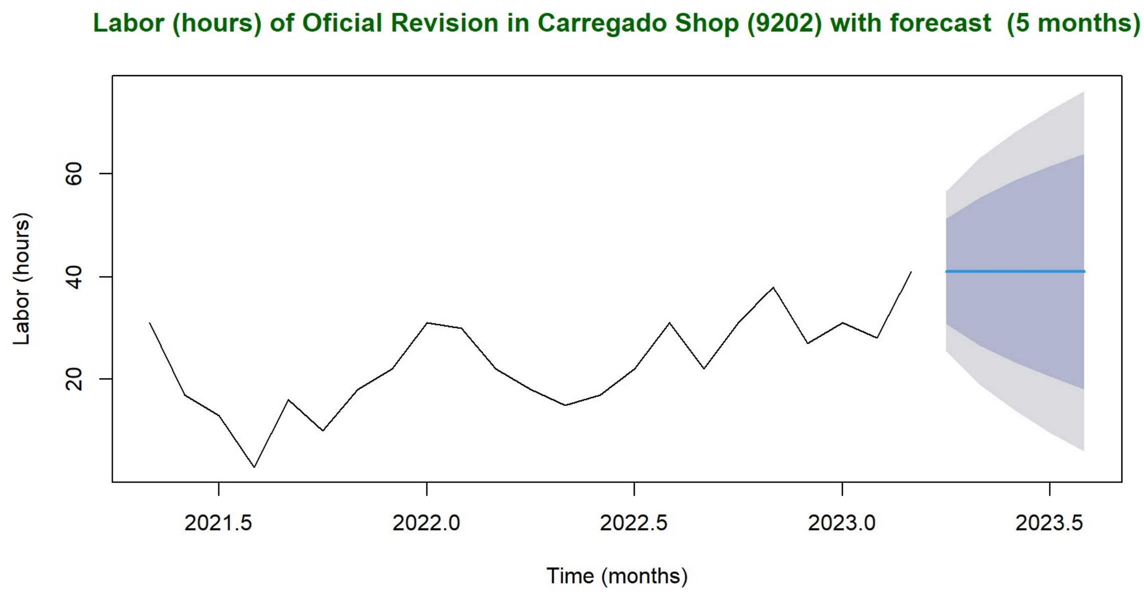


Figure 16 - Labor Forecast Carregado Shop

The forecast performed by R is not as stable for the following months has seen before. Table 16 shows the occupation of this shop in more detail.
In this case the number of hours of occupation surpass higher values than in the past data as shown in Figure 16.

Table 16 - Labor Forecast Carregado Shop

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Apr 2023	41	30.76216	51.23784	25.342571	56.65743
May 2023	41	26.52150	55.47850	18.857051	63.14295
Jun 2023	41	23.26754	58.73246	13.880537	68.11946
Jul 2023	41	20.52431	61.47569	9.685142	72.31486
Aug 2023	41	18.10749	63.89251	5.988924	76.01108

In Figure 17 it is presented Aveiro shop forecast for five months. The data of Aveiro shop was collected from October 2021 till March 2023.

The number of labor hours necessary for the official revision in March 2023 was 77 hours (the last observed value in our time series), and the ARIMA model gives the forecasted number of hours for the next five months as 77 hours as shown in Table 17.

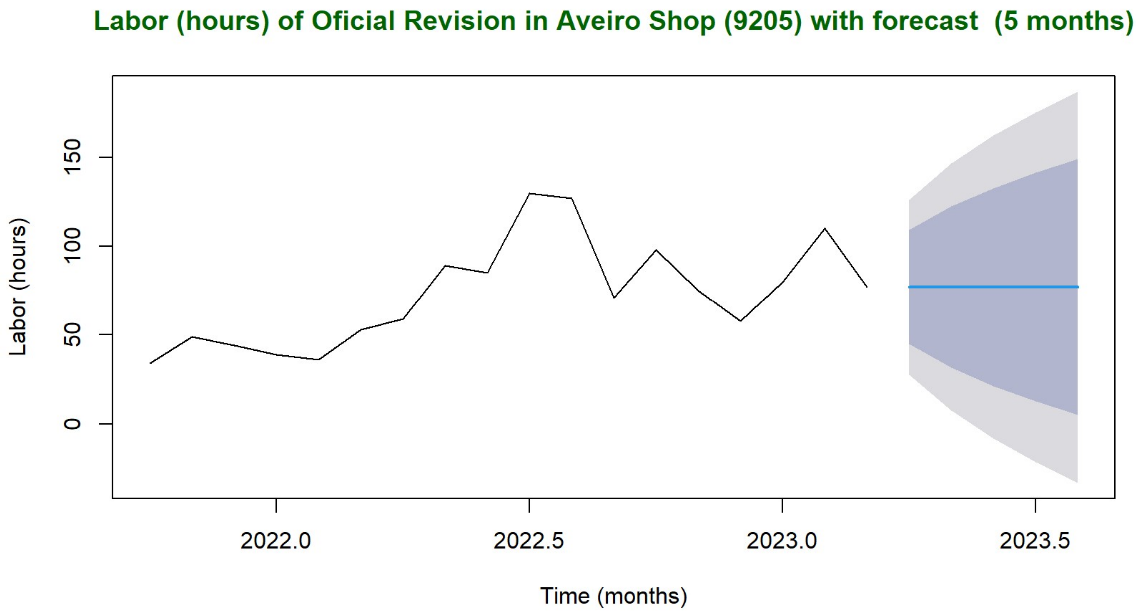


Figure 17 - Labor Forecast Aveiro Shop

The forecast performed by R is stable for the following months. Table 17 shows the occupation of this shop in more detail.
In this case the number of hours of occupation don't surpass higher values than in the past data as shown in Figure 17.

Table 17 - Labor Forecast Aveiro Shop

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Apr 2023	77	44.825802	109.1742	27.793810	126.2062
May 2023	77	31.498812	122.5012	7.411938	146.5881
Jun 2023	77	21.272654	132.7273	-8.227622	162.2276
Jul 2023	77	12.651603	141.3484	-21.412381	175.4124
Aug 2023	77	5.056305	148.9437	-33.028386	187.0284

In Figure 18 it is presented Porto ZI shop forecast for five months. The data of Porto ZI shop was collected from October 2021 till March 2023.

The number of labor hours necessary for the official revision in March 2023 was 134 hours (the last observed value in our time series), and the ARIMA model gives the forecasted number of hours for the next five months as 133 hours as shown in Table 18.

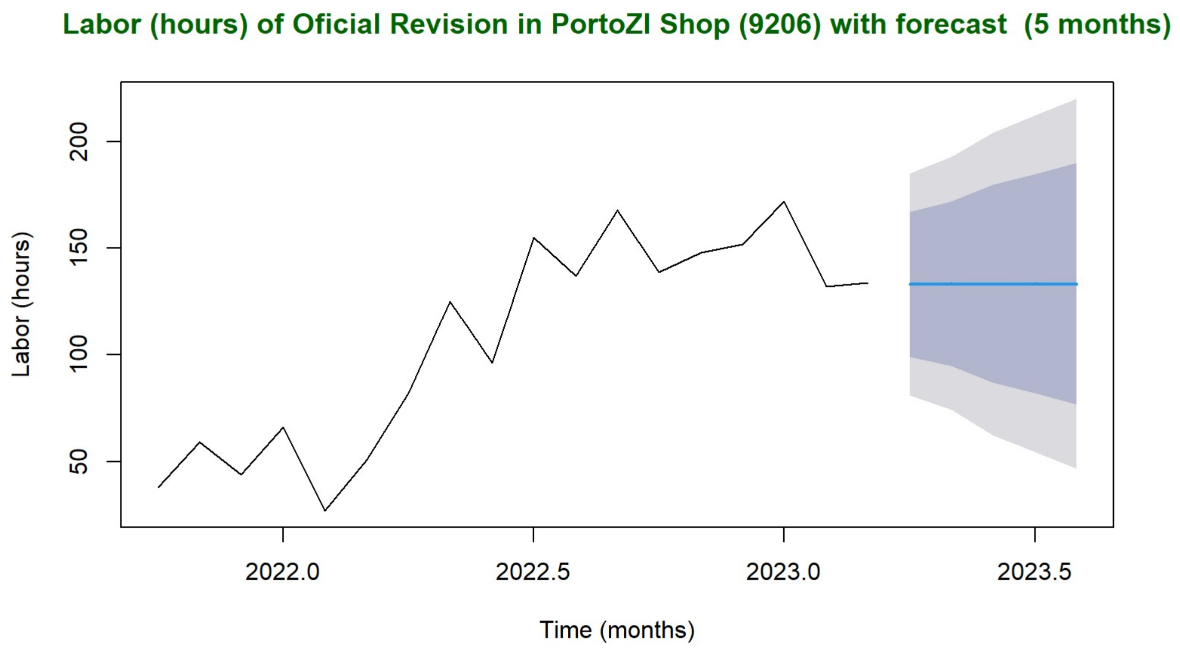


Figure 18 - Labor Forecast Porto ZI Shop

The forecast performed by R is not as stable for the following months has seen before. Table 18 shows the occupation of this shop in more detail.
In this case the number of hours of occupation don't surpass higher values than in the past data as shown in Figure 18.

Table 18 - Labor Forecast Porto ZI Shop

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Apr 2023	133.0849	99.04318	167.1265	81.02260	185.1471
May 2023	133.5036	94.77637	172.2308	74.27541	192.7318
Jun 2023	133.3120	86.89242	179.7316	62.31938	204.3046
Jul 2023	133.3997	81.88790	184.9114	54.61922	212.1801
Aug 2023	133.3596	76.60550	190.1136	46.56172	220.1574

In Figure 19 it is presented Loulé shop forecast for five months. The data of Loulé shop was collected from March 2022 till March 2023.

The number of labor hours necessary for the official revision in March 2023 was 53 hours (the last observed value in our time series), and the ARIMA model gives the forecasted number of hours for the next five months as 57 hours as shown in Table 19.

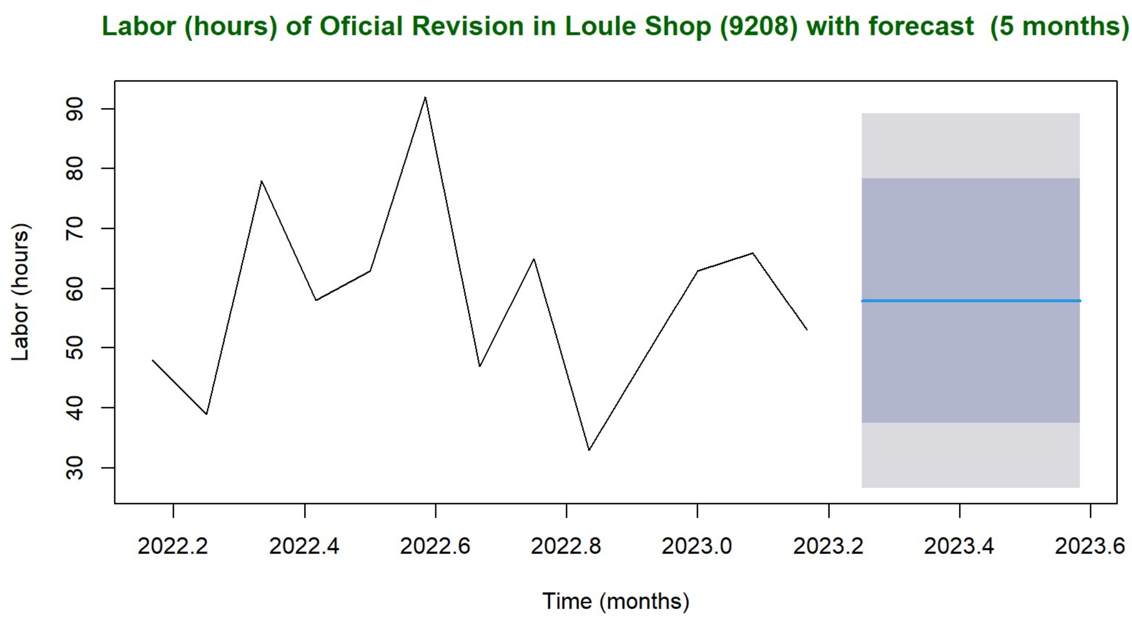


Figure 19 - Labor Forecast Loulé Shop

The forecast performed by R is not as stable for the following months has seen before. Table 19 shows the occupation of this shop in more detail.
In this case the number of hours of occupation don't surpass higher values than in the past data as shown in Figure 19.

Table 19 - Labor Forecast Loulé Shop

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Apr 2023	57.92308	37.48871	78.35744	26.67142	89.17474
May 2023	57.92308	37.48871	78.35744	26.67142	89.17474
Jun 2023	57.92308	37.48871	78.35744	26.67142	89.17474
Jul 2023	57.92308	37.48871	78.35744	26.67142	89.17474
Aug 2023	57.92308	37.48871	78.35744	26.67142	89.17474

In Figure 20 it is presented Odivelas shop forecast for five months. The data of Odivelas shop was collected from November 2021 till March 2023.

The number of labor hours necessary for the official revision in March 2023 was 20 hours (the last observed value in our time series), and the ARIMA model gives the forecasted number of hours for the next five months as 20 hours as shown in Table 20.

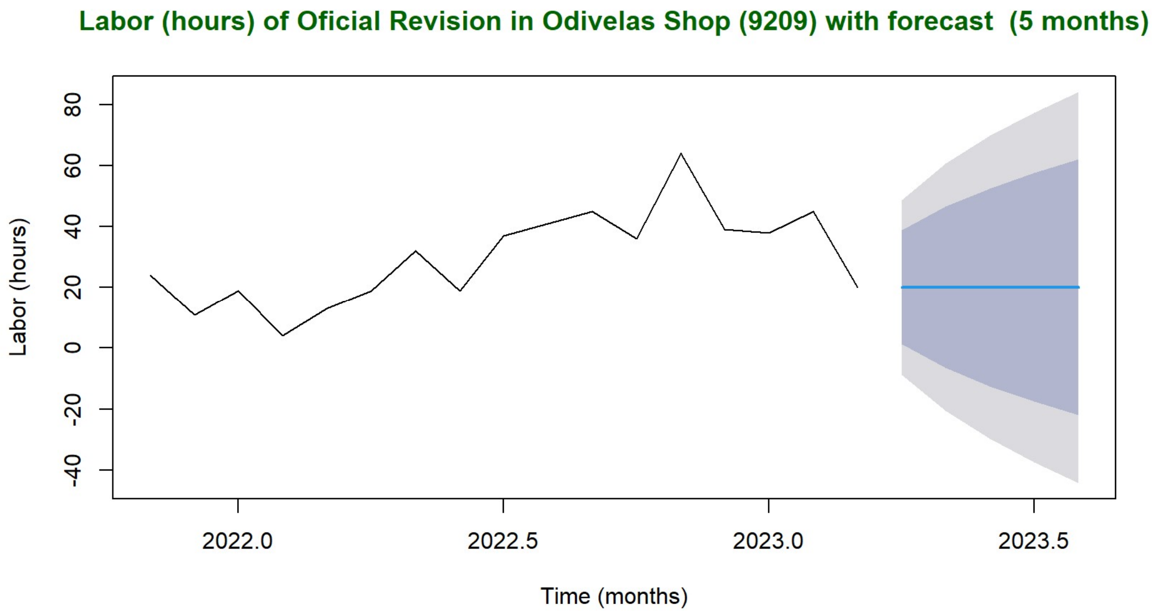


Figure 20 - Labor Forecast Odivelas Shop

The forecast performed by R is not as stable for the following. Table 20 shows the occupation of this show in more detail.
In this case the number of hours of occupation don't surpass higher values than in the past data as shown in Figure 20.

Table 20 - Labor Forecast Odivelas Shop

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Apr 2023	20	1.225159	38.77484	-8.713642	48.71364
May 2023	20	-6.551635	46.55164	-20.607222	60.60722
Jun 2023	20	-12.518979	52.51898	-29.733487	69.73349
Jul 2023	20	-17.549683	57.54968	-37.427284	77.42728
Aug 2023	20	-21.981822	61.98182	-44.205655	84.20566

In Figure 21 it is presented the Vila Real shop forecast for five months. The data of Vila Real shop was collected from December 2021 till March 2023.

The number of labor hours necessary for the official revision in March 2023 was 14 hours (the last observed value in our time series), and the ARIMA model gives the forecasted number of hours for the next five months as 17 hours as shown in Table 21.

Figure 21 - Labor Forecast Vila Real Shop

The forecast performed by R is stable for the following months. Table 21 shows the occupation of this shop in more detail.
In this case the number of hours of occupation don't surpass higher values than in the past data as shown in Figure 21.

Table 21 - Labor Forecast Vila Real Shop

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Apr 2023	17.0625	7.780094	26.34491	2.866285	31.25872
May 2023	17.0625	7.780094	26.34491	2.866285	31.25872
Jun 2023	17.0625	7.780094	26.34491	2.866285	31.25872
Jul 2023	17.0625	7.780094	26.34491	2.866285	31.25872
Aug 2023	17.0625	7.780094	26.34491	2.866285	31.25872

In Figure 22 it is presented the Vila do Conde shop forecast for five months. The data of Vila do Conde shop was collected from November 2021 till March 2023.

The number of labor hours necessary for the official revision in March 2023 was 59 hours (the last observed value in our time series), and the ARIMA model gives the forecasted number of hours for the next five months as 59 hours as shown in Table 22.

Figure 22 - Labor Forecast Vila do Conde Shop

The forecast performed by R is stable for Vila do Conde shop. Table 22 shows the occupation of this shop in more detail.
In this case the number of hours of occupation don't surpass higher values than in the past data as shown in Figure 22.

Table 22 - Labor Forecast Vila do Conde Shop

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
Apr 2023	59	32.997211	85.00279	19.232167	98.76783
May 2023	59	22.226504	95.77350	2.759791	115.24021
Jun 2023	59	13.961849	104.03815	-9.879908	127.87991
Jul 2023	59	6.994423	111.00558	-20.535667	138.53567
Aug 2023	59	0.855997	117.14400	-29.923579	147.92358

4.4. Study of the Viability of Implementation of the Improvements

After the presentation of today's car market, we are now able to study how this change will influence the way shops will operate in the future.

At the moment there is no demand for electric vehicle services in the aftermarket. And, the lower demand that exists are simple services to perform. Any normal technicians that exist in an aftermarket shop is able to respond to the demand that exists today.

Now the market suffers from a resistance and lack of competitivity to the OEM shops. People are not only scared to perform any type of maintenance to their vehicles outside of the dealership's doors, but they also see no gains to do it. When we perform a test of pricing, we are able to understand that the official dealerships have low prices when compared to the aftermarket shops. And the aftermarket sector is not able to respond because with the lower margin business growing and entering the shops, they will face themselves with the challenge to sustain their activity.

The study presented in this thesis warns of a new era incoming. In the future and with the change in the mobility sector the aftermarket needs to set the focus to the costumer, and make sure that value is being added to the serviced performed. This is the only thing that will distinguish a shop from the other competitors.

In summary, this thesis can present a new paradigm to the sector but with the lack of maintenance needed in these new types of vehicles, the lower profit margin, the lack of competitivity and the lack of costumers it won't be easy to perform any type of improvement in costumer care and sustain the operation.

4.5 Discussion of the Data Collected

This thesis meant to reach a few goals. However, as it was presented before we can say that the sector didn't align in time. This meant that the data collected wasn't enough to respond to all the questions intended. For this reason, the scope of this thesis had to be redirected because the data collected show us that the number of entries by shop of EV's is quite reduced. By this lack of data we can already assume that there is a mental barrier when it comes to the aftermarket sector and EV's maintenance.

Nevertheless, we were able o conclude in this study that the number of electric vehicle sales is gaining market and setting records. In today's market the market share of EV's has surpassed diesel combustion engines share.

To summarize, the sector is facing a huge change regarding the new era of mobility and the model that is currently used will not be able to sustain and survive the change of paradigm. This model is at risk because it is not able to support the new era of vehicles that don't have internal combustion engines or cannot be combined with the usual internal combustion engines. The marriage of both technologies was never a threat because it was already known in the sector, the Toyota Prius has been in the market for more than twenty years and the shops are already used to see and work on these types of vehicles and the main reason is that the internal combustion engine is not lost entirely.

Following the study presented in this thesis we can conclude that the main area of income of each shop is centred on high labor rates of repairs performed in internal combustion engines. We were also able to understand that the maintenances performed in these types of engines represent the more profitable areas inside a workshop. For this reason, without the maintenance plans we will be strangling the shops profitability and their economical sustainability.

As concluded in chapter 4. The highest occupancy rate of a workshop is centred on revisions, engine repair services and brake services. Therefore, this new method of mobility presents a risk for the sector, as one of the biggest sources of profitability are overhauls and repairs to the combustion engine, and in electric vehicles this disappears. Also looking at the need for maintenance for one of these vehicles, it is much lower and much more sustainable when compared to that of an internal combustion vehicle. Therefore, not only will the margin on services performed be lower, but it will also result in a lower rate of costumer visits to the workshop per year.

The truth is that in the sector there is still a lack of preparation to receive these vehicles in the workshops and carry out more complex services. The main aftermarket entities have only now shifted their focus to electric mobility and are aware that the sector has to adapt to this new reality. New business methods and the restructuring of services come into force to combat the abrupt decline in margin freed up by services provided to electric vehicles. It seems that not only will the margin decrease when maintaining an electric vehicle, but infrastructure costs will increase due to the need for more specialized labor. This lack of preparation exists because the demand is not reaching the aftermarket industry and when it does the services wanted are simple. Nowadays, workshops are able to respond to electric vehicles without specialized technicians, as these vehicles only use the aftermarket to carry out tire changes, brake services and simple inspections. No technician specialized in electric vehicles is required for this type of services.

The lack of demand we can assume that provides from the official manufacturer shops being able to be competitive in these types of vehicles. They present prices that are similar to the ones offered in the open market. Therefore, the costumer has no financial benefit that makes him chose an aftermarket shop and surpass his mental barrier, that is the trust in the aftermarket shops to work on such new technologies, the idea of large expenses when it comes to some major works on the car, for instances the change of the power supply and that the warranty will be voided.

This lack of entries resulted in few data collected has said before. And to maintain some of the objective of this thesis a forecast was made not for the occupancy of shops in EV's but for the demand in official revisions.

However, with a great amount of data it would be possible to make a more accurate forecast of the working hours needed in each workshop for each service. With the greater amount of date we would also be able to predict service needs for electric vehicles, as, as time progresses, with the number of electric vehicles sales increasing this assures us that the number of electric vehicles that require repairs will also increase.

In conclusion, we can observe that a change is critical. And now is the time. There is a will to make this change hapen, because these main entities are afraid of the future, and they are planning to overcome this "issue" in the best way possible. Some partnerships and brainstorming's times have been implemented between these entities to try to reach a common goal that we like to call "the solution for the EV's". Some of the results point to the costumer care. With these, the better way to give a response to the costumer and to gain their loyalty is to present him with a better experience than the OEM sector.

At the moment we would like to believe that shops will be able to present a better, more valued, solution to the costumer if they start collecting more data from their costumer vehicles. We believe that this will be crucial to give a special treatment to the costumers.

Data progress will enable shops to advise the clients of their vehicle needs and be able to predict issues in a preventive way. Some of the articles presented in this thesis want to go further on this subject and try to implement systems that are able to receive data from the car through cloud uploads. This means that the shop will be able to consult the state of the vehicle whenever they need and be able to give a diagnosis at a distance. This will certainly change the way that the aftermarket business is conducted, and from these articles we can also conclude that the business will be more focused on the client in the future.

Lastly, after the real perspective given of today's car market, we are now able to conclude that shops need to prepare themselves for future demand. For future changes the sector should prepare their teams to be able to perform services with no restrictions on EV's and to be more costumer centred. With this preventive work on the teams, we strongly believe that when the EV's costumers look for a solution in the aftermarket they will be more confident with a rigorous/knowledge posture from the aftermarket sector.

5. CONCLUSION

In this chapter final conclusions will be displayed, as well as limitations and future work.

5.1. Final Conclusions

This thesis shows that the sector evolved to a new era of mobility. Manufactures have set the pace to a global change in the automotive sector. Studies tell us that the electric vehicles (ECVs) and hybrid electric vehicles (HEVs) sales are evolving in the last years. In fact, the car market sales of ECVs have grown 53% between 2018-2019 (210% between 2015-2019) and HEVs has grown 49,8% between 2018-2019 (310% between 2015-2019). In terms of global car market share these types of technology have growth 2% for the ECVs and 4% for the HEVs since 2015 till 2019. Also, it is important to relate that the car market share of diesel-powered vehicles has lost 21% of his market share since 2015. With this is clear to say that these new types of technologies are implemented and becoming to have significant influence in our car parc. And that is time for a change in the sector.

When we look to the sector and try to learn the impact that this new era can have on the aftermarket industry, we understand that these new types of mobility use more sustainable sources of power only with electric engines. In chapter four, we were able to identify that the main areas of income of an aftermarket shop are related to the internal combustion engine, so we can assume that this is the first type of mobility to threaten this sector in years. Thus, following the study presented we can envision that with these new technologies gaining a higher market share shops will face a decrease in the entries of internal combustion engines services and, when it comes to profitability, we have established that this will result in a lower profitability than todays.

Regarding the last objective presented in this report, we conclude that a change is in need. The sector is now concerned, and they must change paradigm before it is too late. Competitiveness is higher than ever, and for that reason shops should look to change their management approach to a method that is closer and more transparent to the costumer. The costumer will require a special treatment that the shop will be able to present using cloud solution to have a live data feed from the costumer vehicle to give a diagnosis at a distance. This will certainly change the way that the aftermarket business is conducted and add more value to the costumer.

In conclusion, this thesis can set a new awareness to the sector and show him that the new era is already here. So, it’s crucial that sector changes paradigm.

5.2. Limitations and future work

The main limitation in this thesis was the data collection. Since the study was performed in Midas PT it was not possible to recover data for an upper period than 2 years, because in 2020 the master franchise of Midas Europe and South Africa selected a new master franchisee for Portugal, in this case Salvador Caetano Group. For this reason, the project was restarted from zero with no shops open to the public and no data from the past years. From the eight shops selected for analysis on this thesis they all were opened to public in 2021.

Even more, one of the objectives of this thesis was to respond to how would the aftermarket sector deal with the new era of mobility, electric vehicles, and how should the sector prepare itself to respond to the needs of these costumers, but the data that was collected between eight shops wasn´t enough to respond to this matter. We had almost no entries regarding electric vehicles, therefore it is impossible to build a study and to respond to an objective with any support from data. For this reason, we were only able to give our inner thoughts on the matter.

In addition, the software used to treat the data and create the graphics/tables used in this work was complex and required several hours of studie to use. For this reason, the first impact wasn't the best making an impact in the work that was developed in this thesis.

For future work a great amount of data would make a more accurate forecast of the working hours and predict service needs for electric vehicles. We would also be able to reproduce the forecast study to all the services performed in each shop and give an accurate forecast for all their labor needs. The same study can be replicated for the invoice value of each shop.

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