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Approaching and distancing factors of Electric Vehicle consumers

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by

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Abstract

The present study aims to identify the factors approaching and distancing users from the purchase of electric vehicles. The main objective is, therefore, to determine which characteristics - of the vehicle, the service and / or the external context - lead consumers to make the decision to buy or not buy this type of automobile.

A qualitative analysis of 5 interviewed professional from the EV sector was conducted, followed by the analysis of 250 questionnaire target market's responses.

The results predict that the Environmental Performance (EP), the Governmental Tax incentives and TCO (TAX_TCO) as well as the Maintenance cost reduction (MCR) EV's attributes are the greatest consumption Approaching factors. On the other hand, the Charging facilities availability (CFA), the Time cost of charging and the Driving experience (DE) are suggested as the attributes most distancing consumers from a purchase.

Furthermore, other conclusions were drawn particularly concerning the significance of test-driving experiences and EVs. Moreover, findings also suggest that non-EV owners perceive greater autonomy for PHEVS than users who currently own an EV.

Finally, key takeaways were drawn, aiming towards a greater EV's sales success rate, EV customer's satisfaction and an overall increase in demand and market share.

KEYWORDS:

Electric vehicles. Consumer behaviour. Product attributes.

Sumário

O presente estudo tem como objetivo identificar os fatores que aproximam e distanciam os consumidores da compra de veículos elétricos. O objetivo principal é, portanto, determinar quais as características - do veículo, do serviço e / ou do contexto externo - que levam o consumidor a tomar a decisão de comprar ou não este tipo de automóvel.

Uma análise qualitativa a 5 profissionais do setor entrevistados foi primeiramente conduzida, seguida de uma análise quantitativa de 250 respostas a um questionário desenhado e proposto ao público em geral.

Os resultados preveem que o Desempenho Ambiental, os incentivos fiscais governamentais e o custo total da posse, bem como a redução de custo de manutenção, são os atributos dos veículos elétricos que mais aproximam os consumidores da decisão final de compra. Por outro lado, a Disponibilidade de Instalações de Carregamento, o Custo do Tempo de Carregamento e a Experiência de Condução são apontados como os atributos que mais distanciam o consumidor de uma compra.

Para além destas, outras conclusões foram tiradas, particularmente em relação à importância das experiências de *test-drive*. Mais ainda, os resultados obtidos também sugerem que os indivíduos que não são proprietários de veículos elétricos pontuam estes com maior autonomia do que os usuários que realmente possuem um.

Foram assim traçadas conclusões ao nível empresarial, visando uma maior taxa de sucesso de vendas de Veículos elétricos, de satisfação de clientes de VE e um aumento geral na procura dos mesmos.

<u>PALAVRAS-CHAVE:</u>

Veículos elétricos. Comportamento do consumidor. Atributos do produto.

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List of Acronyms

AVAS - Approaching Vehicle Audible System

BEV – Battery Electric Vehicle

EV – Electric Vehicle

FCEV – Fuel Cell Electric Vehicle

HEV – Hybrid Electric Vehicle

ICEV – Internal Combustion Engine Vehicle

NEDC - New European Driving Cycle

PHEV – Plug-In Hybrid Electric Vehicle

SOC – State of Charge

TCO – Total Cost of Ownership

VKT – Vehicle Kilometers to be travelled

WLTP - Worldwide Harmonized Light-Duty Vehicles Test Procedure

Chapter 1

Introduction

As the world becomes increasingly aware of the importance of its ecological footprint, we are witnessing significant discoveries that lead to the launch of new opportunities in the market. Electric vehicles have not only proven to be sustainable, but their demand has been increasing over time (Cazzola, 2018). Thus, it becomes increasingly important to get to know the consumer of these type of vehicles, and hence understand what brings them together and what distances them from the acquisition of this value proposition. It is already clear that the future will pass through the growing adoption of these models (Cazzola, 2018), and the business that manages to gain greater market share will, from the outset, be the one that brings together the greatest number of advantages for its user. Bearing this, the present study aims to identify the factors approaching and distancing users from the purchase of electric vehicles. The main objective is, therefore, to determine which characteristics - of the vehicle, the service and / or the external context - lead consumers to make the decision to buy or not buy this type of automobile.

Chapter 2

Literature Review on Electric Vehicle's Purchase

The automotive industry has been evolving ever since the first car touched the road. We nowadays face a bigger and faster evolution than has ever been registered, driven especially by the need to sustainably save our planet. Namely, Battery-Electric vehicles (BEVs) are currently seen as one of the biggest changes being made towards this goal, and the general public is being pushed by brands and governments towards these technologies (Zhang et al., 2014).

Records state the first Electric Vehicle (EV) was produced in 1835. However, only in 1891 was the first practical and fully functional EV presented (Deng, 2020). For several years, EVs were not an option for most consumers, however, the Oil crises of 1970´s, most known as the "Oil embargo" (Painter, 2017), shifted this mindset. This is said to be so, as EVs strongly battled against Internal Combustion Engine Vehicles (ICEVs) (Deng, 2020), ultimately rendering petrol-oil obsolete.

Nevertheless, Battery-Electric Vehicles have faced several constraints in penetrating the market, specially since this technology is directly competing with ICEVs that have a strong ongoing presence in the marketplace, whilst proving to be reliable over the years (Sataloff et al., 2018). Thus, product attributes, such as price, brand and technical attributes, will ultimately influence customers choices, over which product/car they will adopt next (Kostyra et al., 2016). By identifying such, this study hopes to investigate and understand which technical attributes, referred to as intrinsic factors (Enneking et al., 2007), and social influences (i.e.

extrinsic factors), will act as consumer approaching or distancing factors. For this reason, studying such factors, considering this market's consumers buying intentions, will help to determine the extent to which EVs market share will potentially grow in the near future.

2.1 Approaching factors influencing EVs purchase

Several studies have analyzed the buying process of the automotive industry's consumers, with particular emphasis to Electric Vehicles (EV) buyers, due to their uniqueness (Zarazua de Rubens, 2019). Accordingly, in the EV segment, the **buying price** is pointed to as the main factor influencing consumers during the buying process (Vilchez et al., 2019). Interestingly, existing literature points out that, in the latest years, consumers have been changing their opinions regarding the price of Battery Electric Vehicles (Gómez Vilchez et al., 2017). In fact, evidence suggests that, over time, fewer buyers consider the price of EV batteries as "quite expensive" (Gómez Vilchez et al., 2017), when comparing to results from older research findings.

One of the reasons for this shift could be the improvement of the cost competitiveness of this technology in the latest years, particularly after the introduction of **government incentives** in the form of purchase subsidies, ultimately lowering EVs price tag (Gómez Vilchez et al., 2017). Notably, government incentives are said to play a significant role but it´s relative importance and effectiveness shifts depending on the economic power of the consumers of different countries (Vilchez et al., 2019), and the price category of the vehicle (Cecere et al., 2018).

Furthermore, a quantitative research surveyed in Germany (Degirmenci & Breitner, 2017) points out that the main influencing buying factor of EVs is the **environmental performance** achieved when comparing to internal combustion engine vehicles. Findings also defend that consumers are noticeably gaining more knowledge about sustainability and ecology. Subsequently, building this awareness, enables potential buyers to accurately identify EVs environmental performance as a differentiation factor (Gómez Vilchez et al., 2017).

Illustrative of such is the study made by (Teixeira & Sodré, 2018), which presents several scenarios regarding the Brazilian energy production grid. Their final results state an 8-points energy reduction use when including EVs on the national fleets, mainly explained by the higher energy conversion of EVs when comparing to Internal Combustion Engine Vehicle (ICEV). The author went to the point of stating that, even in the worst-case scenario in "which hydropower generation is largely replaced by thermopower generation" EV´s CO_2 emissions will be 10 times lower in 15 years than the ones observed from ICEVs. These forecasts are thus considered, by some consumers, as attractive reasons for the purchase investment in an EV.

Moreover, **fuel costs** were pointed out as the second most important factor when buying a vehicle in almost every inquired country. Nowadays consumers are starting to realize the economic benefits of driving electric vehicles daily, when comparing to traditional internal combustion engine vehicles, due to the high prices of fossil fuels (Gómez Vilchez et al., 2017). However, distinctively to the remaining findings, in Poland, the second most important factor was the **maintenance cost** (Vilchez et al., 2019), suggesting geographical segmentation may reveal significant differences between consumers.

Other conclusions (Vilchez et al., 2019) also report the car's **brand, safety, comfort** and **insurance costs**, as influencing factors, persuading consumers towards the purchase of EV.

Findings on the significance of factors such as **free parking** and **toll reduction**, which had also been hypothesized as potential factors positively influencing the number of EVs bought, lack substantial evidence corroborating their statistical significance (Tu & Yang, 2019).

2.2 Distancing factors inhibiting EVs purchase

Despite at first sight looking like an enticing purchase, EVs continue to nurture a number of factors that constrain a final purchase decision. **Driving range, charging duration** and the **density of charging stations** also influence the buying process of Electric Vehicles, which actively demonstrates the importance of charging infrastructure's development to the secure the successful future of the EV market (Tu & Yang, 2019).

In fact, EV preference studies investigating consumers choices conclude there are still several consumer-perceived **uncertainties** surrounding EVs. These, among others, encompass the EV's **controversial environmental performance**, the **battery's life**, **charging facilities availability** and **depreciation** (Tu & Yang, 2019). Given such, literature (Egbue & Long, 2012) considers that uncertainty, and the attributes that nurture it, are the main barrier for EVs adoption at this point.

Furthermore, whilst some perceive EVs as eco-friendly and hence consider their **environmental performance** as a positive influential factor, contributing towards the purchase of these cars, others think otherwise. As mentioned, emissions and overall environmental performance of EVs highly contribute to this market's growing share. The results presented by (Teixeira & Sodré, 2018) demonstrate that CO_2 emissions from an EV fleet can be 10 to 26 times lower than those from an Internal Combustion Engine Vehicle (ICEV) fleet.

It is known that vehicles powered by internal combustion engines are an important source of pollutant and green-house gases (Baran & Legey, 2018). The transportation sector accounts for almost a quarter of global CO_2 emission (Teixeira & Sodré, 2018), and so, growing environmental concerns have put EV technology on the path of the main automotive industry developers. As an example, the German automobile manufacturer specializing in high-performance vehicles, Porsche AG, has accelerated the development of EV solutions (AG, 2020).

However, EVs pollution rates may be considered controversial as the real impact of these vehicles emissions is linked to the energy needed for their use (Lombardi et al., 2017). Namely, the main controversial factor attached to EVs is the pollution seen in the production phase of the batteries, which according to (Bickert et al., 2015), will continue to cause more damage to the planet in 2030 than the production of ICEVs.

This clearly shows that different authors are presenting different conclusions regarding the overall impact of EVs on the environment and hence, it is understandable that the same discrepancies between opinions occur in the minds of consumers.

Furthermore, several studies have highlighted the significance of EV's **charging infrastructures** in consumers purchasing decision (Harrison & Thiel, 2017). The study by Morrisey et al., (2016), presents findings regarding the use patterns of different charging infrastructures, stating that "*Standard charge points were found to be utilized to a greater extent earlier in the day with fast charge points utilized more in the evening and night*."

The findings presented by Morrisey et al., (2016) are supported by the observation of the day-to-day activities: The majority of people, including EV users, commute to work every morning and only return home at the end of the day. So, most of them plug their vehicles at standard chargers, installed near their work locations, being the only type of charger available and coinciding with the time available to charge the car for a longer period, the average charging time in public standard chargers being 3 hours (Morrissey et al., 2016).

At the end of the day, an energy peak was recorded in this particular study, stating that EV users prefer to charge their vehicles immediately after arriving home from work. So, "home" is stated as the preferred place to charge vehicles and also recorded the average longer period of charging. But this early evening recharging peak presents a problem since it coincides with the peak period of household electricity consumption (Sun et al., 2015) and in some cases, it was already linked with the overload of some electric grids, such as the Californian one.

Recharging a car at home is preferred by users but wouldn´t this present a logistic problem in big cities? BEVs may experience lower sales volume in city centers, since urban conglomerates are full with historic buildings with shared garages or even no garages at all, meaning that residents have no private infrastructure solutions to charge their EVs (TIAGO ISIDRO DA COSTA, 2014). This is thought to cause negative implications to consumer who would, otherwise opt for this type of vehicle but which, faced by such limitations, decide otherwise. Given such, future research could assess whether demographic indicators such as type of housing and average household income influence the significance of the role of charging infrastructures during the decision-making process of purchasing an EV.

For instance, Electric Vehicles from higher/luxury segments, such as the Porsche Taycan, may not be affected by this issue, since their target consumer is likely to live in high-end apartments with closed garages, or private homes, increasing the probability of becoming easily equipped with charging infrastructures.

When assessing EV consumers behaviours, the study by Morrisey et al., (2016) portrays that, similar to ICEV users, petrol stations were found to be used for short periods by EV users. Some EV consumers were seen using standard chargers as a "*top-up*" while enjoying a break from their trip or using fast chargers to be able to reach quickly their final destinations. The authors Morrisey et al., (2016) also present a case study stating that for commercial purposes, car park locations are the most viable solution, and fast-charging stations present the most profitable infrastructure in the medium to long term period. The conclusions taken from this research is that, depending on the usage the vehicle will have, consumers will opt for different alternatives. We hence foresee that different consumers, with different lifestyles, will value EVs attributes to different degrees.

Given such, to better understand the usage of charging infrastructures and consumer behaviour, one must recognize the main motives of each type of user that ultimately lead to the need for recharging. As indicated by Sun et al., (2015), commercial and private users have different uses and needs for the vehicle. His estimation results show that the State of Charge (SOC), that is, interval days before the next travel day, and the Vehicle Kilometers to be Travelled (VKT), that is, the distance to be travelled on the next travel day, are the main factors considered by users when choosing to charge their EV. It was also pointed out by some studies that "*the experience of fast charging decreases the probability of normal charging*" (Sun et al., 2015), indicating that the probability of normal charging after the last trip of a working day is higher for commercial EV users.

Furthermore, uncertainty regarding the choice for EVs also lays on the still existing doubts about EVs **battery life cycle**. Due to *Power fade,* that is, the loss of cell power caused by increased cell impedance from aging (Lawder et al., 2014), and *Capacity fade*, defined as the loss of energy storage capacity due to degradation caused by cycling (Lawder et al., 2014), EVs and PHEVs batteries have to be replaced at some point and this causes some uncertainty to some consumers pondering on the decision to invest in this type of vehicles. Knowing that batteries replacement tends to be expensive may, therefore, be considered a distancing factor.

Based on present established requirements, batteries that have lost 20%, or more, of their initial factory capacity are no longer useful for automotive use and should be replaced (Cready et al., 2014). Despite this fact, batteries are more and more gaining capability with developments being made, and "are now expected to last more than 200 000 km" (Wang et al., 2017).

This is said to be true as, the life cycle of EV batteries does not only depend upon its power and capacity fade, turning out as an uncontrollable attribute in consumers-optic. Natural degradation is a degradation process that is independent of the usage and charging and discharging cycles of the battery, known as Calendar Life (Lawder et al., 2014). It is, therefore, concluded that charging and discharging cycles of the battery are also factors taken into account by potential buyers, when considering the degradation of a battery during their vehicle's purchasing decision making process.

Finally, as this is a relatively new technology, the many aspects of the **total cost of ownership of EVs** may still be unclear for potential consumers (13). Factors such as the incentives towards the purchase of an EV, the necessity for battery replacement at some point in the vehicle useful life period, the cost difference between electricity and fuel, the long-term costs of owning an EV, such as the resale value, and others, are being overlooked by several studies.

So, according to (Danielis et al., 2018), in what concerns the total cost of owning a Battery Electric Vehicle, sellers must develop a probabilistic total cost of ownership model (TCO) considering several costs, which should then be disclosed to customers. Ideally, this step will help consumers understand the cost-effectiveness of investing in EV. For example, Weldon et al,. (2018) defend that a complete TCO model considers the purchasing price, fuel economy, resale value of the vehicle, vehicle usage, maintenance costs and also governmental incentives.

Interestingly, existing data provides evidence that EV's TCO in 2014 was higher than in 2017, especially when considering governmental policies / incentives in the purchase process (Danielis et al., 2018).. However, the TCO of EV is still higher than that of owning an ICEV, especially a Petrol one (Weldon et al., 2018). Acknowledging such can obstruct consumers purchase of EV. However, consumers should also acknowledge that the TCO of an ICEV is very dependent on oil price fluctuations (Weldon et al., 2018), while the TCO of an EV is more dependable on the technological developments that ultimately can lower the acquisition price of the vehicle. For example, a long term 10 years TCO prevision in the Korean market was drawn by (Weldon et al., 2018), considering the actual speed of development, and the main predictions are that EVs will be cheaper to own, even if the oil prices decrease by 20% by this period.

In fact, this is one of the subjects with the biggest research gap regarding EVs since several authors designed their own TCO models, but almost none considered costs such as the **time cost of refueling**. As proven by existing literature (Sun et al., 2015), EVs take too long to charge, and this presents a big cost. **Charging infrastructures** also represent an overlooked cost to individuals that choose to buy one for home charging, or even for companies that decide to invest in public charging stations.

In what regards **social costs**, only Delucchi & Lipman (2001) described these expenses associated with the use of BEVs relative to ICEV, including noise, externalities of oil use, climate change, and air pollution and estimated these social costs account for $1.09/mile savings for BEVs over ICEVs.

Despite such, when comparing to hydrogen fuel cell vehicles, BEVs maintain a strong cost advantage over this type of technology (Veziroglu & MacArio, 2011), but this cost advantage may quickly reduce by 2030, mainly due to the accentuated cost reductions in FCEVs relative to those of BEVs. This could be so, especially with the assumption that the technology developments of FCEVs will be faster than those seen in BEVs. The results only provide advantages for hydrogen technology when considering larger vehicle segments, while BEVs will probably always present better overall results in smaller vehicle segments.

Another constraint when developing the TCO model for EVs is the fact that the future may even not go through BEVs (Veziroglu & MacArio, 2011), as new technologies such as hydrogen fuel cells are being developed and can be more efficient than batteries as the ones we have today.

Furthermore, when studying EVs and their differences regarding ICEVs, we have to go through the **sound** factor. Combustion cars have been around for ages and people are used to living around them and their characteristic sounds. For pedestrians, the sound of ICEVs is used as an instrument of safety, especially for blind pedestrians who trust these sounds to know when to cross streets, as an example. With the introduction of Electric vehicles, and their well-known soundless characteristics "…groups representing people who are blind have expressed concerns…" on behalf of the noise-less characteristic of EVs (Hastings et al., 2011)

To create a safer environment for pedestrians but not overlook sound pollution, a system called the Approaching Vehicle Audible System (AVAS) was created. Conducted studies, such as Mlit and Jasic (2010), conclude that AVAS are "a realistic alternative for pedestrians who are blind or visually impaired." (Hastings et al., 2011).

The AVAS system doesn't emit a constant and linear sound. Instead, it recreates several situations such as a vehicle approaching at low speed (forward), a Vehicle approaching at low speed (backwards), a Vehicle slowing down (deceleration), a Vehicle accelerating from a STOP, Vehicle stationery and even a Vehicle Starting Up sound (Hastings et al., 2011). This system is obligatory and ultimately alerts pedestrians of vehicles presence and operation, with the least annoyance possible.

The main conclusion is that EVs need the AVAS to securely be driven on public roads and be as easily detected as Internal Combustion Engine Vehicles (Parizet et al., 2013). Several studies conducted on this issue focused on the frequency of the sound used on the AVAS system, finding out that some sounds have characteristics that alert pedestrians but increase annoyance, while others don´t even activate humans' sensorial cells, not causing a positive effect on the safety of EVs. Since the general requirement for the design of a warning sound is a low annoyance but high detectability (Lee, 2012), several authors keep on studying this subject and the AVAS system is in constant mutation.

Thus, it is concluded that although sound may be an inhibiting factor in the purchase of EVs, there are already alternatives that tackle such adversity and, in turn, may induce the purchase. But in what concerns Vehicle Sound, it´s not all about safety. Several papers have been pointing out the importance of sound quality for vehicle design (Kim et al., 2009), mainly in modern luxury passenger cars, but this is a complicated matter since there are a lot of sounds that can compromise the overall interior sound of a passenger car. According to the results presented by a survey designed by (Kim et al., 2009), the most important sounds are engine sound and mechanical–electrical sound. The engine sound is dominant during acceleration and the dominant mechanical–electrical sounds are turning signals and the door lock sound.

Unfortunately for some consumers, most luxury car consumers do enjoy a powerful acceleration sound, which is not possible to achieve in standard EVs unless car manufacturers produce a fake sound transmitted by the interior speakers. So, EVs are known for being soundless, which ultimately, they aren´t, due to the AVAS system, and this characteristic might be good for certain costumers' segments but presents a potential problem to target the luxury car segment.

Porsche is known for creating some of the best sport/luxury cars around, and their new electric vehicle, the Taycan, is no exception. But even Porsche had to tackle the sound of their new vehicle and came out with their sound system: "Porsche Electric Sport Sound", which clearly distinguishes the Taycan powerful acceleration power (AG, 2020).

Cars, as we know them, are changing rapidly, and the sound is not the only difference we can observe between EVs and internal combustion engine vehicles. We have touched several points that separate the two worlds, and the main one, at least for now, is the ability to travel several kilometers without interruptions. But, what if the low energy storage capability of the batteries we have seen nowadays in EVs, doesn't only affect the number of kilometers travelled without stopping (i.e., **EV's autonomy**) (Evtimov et al., 2017)?

Several authors have been conducting studies analyzing "the impact of different auxiliary systems of electric cars on the travel distance in different running conditions and comfort (such as temperature in the car, using lights, audio system, etc.)" (Evtimov et al., 2017). There aren´t enough studies regarding the impact of external temperatures on the overall performance of EVs, but it is also known to be a factor to consider when calculating the total distance a driver is able to travel with his EV, as proven in an investigation conducted on Nissan Leaf (Iora & Tribioli, 2019).

When considering traditional cars, comfort is associated with the driving position, the seat angle, headroom, and others. Consumers often forget about other remaining factors such as temperature and clear vision, because these are usually taken for granted. However, when travelling with an EV, every single piece of energy used may mean one more stoppage to recharge the batteries, and so, firms, sellers and buyers inevitably must consider these.

The **energy consumption** of the light system, as an example, depends on a twenty-four-hour period, but if a driver travels by night, he will need to have the lights on. Ultimately, this will mean more energy consumption. Light and signalization systems will consume about 1% of the energy used to run an EV (Evtimov et al., 2017).

Another system taken for granted in ICEVs is the Air Conditioning system. Farrington and Rugh (2000) point that the impacts of air conditioning on BEV range using legislated driving cycles in the U.S and reported a range decrease by 18–38%, dependent on the test procedure used. So, could drivers achieve maximum comfort when travelling with an EV?

The answer will highly depend upon the distance travelled. When travelling long distances, individuals have to do some estimates before going to the road. In 2014 the legislated drive-cycle test for BEV certification in Australia was done with all auxiliary devices switched off (Jensen & Mabit, 2017), which meant that the real driving range, especially in cold weather, would be lower than the one presented by manufactures. *WLTP* (Worldwide harmonized light-duty vehicles test procedure) began to be implemented as the primary test to determine CO_2 emissions, pollution levels and driving range in September of 2017. Before WLTP, *NEDC* (NEW European Driving Cycle) was the test responsible for these functions but remained unchanged from 1997 and was simply a laboratory test, not containing real driving data (Pavlovic et al., 2016).

WLTP presents several changes, such as dynamic test cycles, longer-lasting test cycles, higher test distances, higher average speeds and the influence of optional extras and others. These additional features in the WLTP test when comparing to the NEDC, brought results closer to real life, but still don´t represent equal results from what we may experience during daily rides. This comes with the fact that even with these new test cycles, auxiliary devices, such as air conditioning, are switched off when testing (Facts, n.d.).

2.3 Future investigations on EV and consumer behaviour

The recency of EVs market share gain and the sector's on-going rise in significance, make this a topical topic. As such, it is noted that there are still no statistically significant data for concrete conclusions to be drawn regarding the factors approaching and distancing consumers from the purchase of EVs (Tu & Yang, 2019).

Besides, from the reviewed literature, it becomes clear that, in the research point of view, former studies fail to discriminate the vehicle considered by consumers when recording their buying preferences. This is a particularly significant element as former research proves that consumers look for different attributes when buying a new versus a second-hand vehicle (Tu & Yang, 2019). Given such, conducted studies on this matter should ask respondents to think about one particular vehicle case (new or second-hand) and discuss results accordingly. Moreover, research should characterize the typology of the EVs and of the consumers in study so that potential distinctions are further identified. For example, will the consumer approximation factors for Battery Electric Vehicles (BEVs) be the same as those of Plug-in Hybrid Vehicles (PHEV)? Or even, will the main divergent elements, hindering EV purchase be the same between consumers who own and consumers who do not own an EV. Will non-EV owners' value certain characteristics more than those who do? If so, which and why?

By identifying this research gap, we critically evaluate current literature and its findings and suggest future research work. For instance, this present paper intends to assess one of these formerly identified gaps. In short, this chapter has broken down the following approach and distancing factors of EVs purchase, given existing literature's findings:

Table 1: EVs purchase approaching and distancing factors

Approaching factors	**Distancing factors**
Purchasing price & governmental incentives	Total Cost of Ownership (TCO)
Environmental Performance	Controversial environmental performance
Fuel cost reduction	Charging facilities availability
Maintenance cost reduction	Charging Duration / Time cost of charging
Brand	Battery life cycle
Safety	Depreciation
Comfort & Driving experience	Driving Range / Autonomy
Social costs reduction	Sound

Given such, this investigation aims to identify and determine which of these outlined characteristics - of the vehicle, the service and / or the external context - lead consumers to make the decision to buy or not buy this type of automobile. Furthermore, it hopes to distinguish the perceptions of consumers who are currently in the process of purchasing an EV and those who are not. Hence, it is hypothesized that:

Hypothesis 1: *Consumers currently in the process of purchasing an EV, value different attributes than the remaining consumers.*

Hypothesis 2: *Sales strategy for EVs must be different than that of ICEVs by highlighting consumer approaching attributes.*

From such an analysis, this study intends to verify the role of individual differences within this customer segment and provide the market with understanding regarding the approaching and distancing factors which are either inducing or inhibiting consumers from purchasing EVs. From these findings, firms will manage to adapt their sales and marketing strategies in order to tackle the perceived attributes currently constraining some potential customers from purchasing EVs. This will, therefore, provide businesses with useful findings for future works.

Chapter 3

Methodology

To provide answers to this research's proposed objective, a mixed approach was used, both quantitative and qualitative, of a theoretical nature, with a purely exploratory data analysis, using a questionnaire and interviews as the main data collection procedure. Interviews approached professionals from the automobile sector and their perspective whilst the questionnaires focused on customer's point of view.

A total of 5 semi-structured interviews were conducted and used as a complementary method, since they base themselves on the interaction between the interviewee and the researcher, making it possible to obtain more specific data and alternatives to those previously planned by the latter.

All interviews were conducted on dates previously agreed with the interviewed subjects, with the possibility of choosing between face-to-face or online format, due to the epidemiological conditions experienced at the time of the study. The interviewed subjects were chosen purposely due to the characteristics of the positions they occupy at car industry companies.

These interviews were recorded in audio format, with the consent of the participants and, later, transcribed in chronological order to carry out their statistical analysis. Each participant was assigned a letter, corresponding to the same chronological order in which data collection was carried out. The interview guide was requested in advance by several of the participants, but their request was deliberately denied to better maintain the credibility of the interview.

Finally, four online interviews and one face-to-face interview were conducted, with similar final results. From these, specific conclusions were gathered which required further clarification.

Given such, an online questionnaire using a 5-point *Likert Scale* was designed for the collection of quantitative data, to better understand the trends being observed in this study from the customer's perspective. The questionnaire was randomly distributed among subjects of various ages and on different digital platforms, thus creating a different and representative sample of the population in general. A total of 331 responses were obtained during the analysis period between the end of November 2020 and March 2021. The questionnaire included the following statements regarding BEVs and PHEVs:

Table 2: Online Questionnaire Constructs & Items

Construct (Approaching & Distancing)	**Items**
Environmental performance	The electric vehicles are more environmentally friendly when compared to combustion vehicles.
Sound	The electric vehicle has a more pleasant sound than that emitted by a combustion vehicle.
Comfort	The electric vehicle is more comfortable when compared to a conventional vehicle.
Driving Experience	The electric vehicle has characteristics favorable to sports driving.
Driving Autonomy	The electric vehicle has sufficient autonomy for my use.
Time cost of charging	The electric vehicle charges its battery fast enough for my use.
Charging Facilities Availability	There are enough charging stations for electric vehicles.
Maintenance cost reduction	Maintenance of the electric vehicle is less expensive than maintenance on a combustion vehicle.

Construct (Approaching & Distancing)	**Items**
Purchasing price / governmental incentives / TCO	The electric vehicle has tax advantages in the purchase process.

Score options ranged from 1 (totally disagree) to 5 (totally agree). As all items favor EVs, the higher the score for each construct, the greater the construct acts as an approaching factor.

Furthermore, the questionnaire also included respondent's characterization questions such as:

i. Are you currently in the process of acquiring an EV?

ii. Do you own an EV?

iii. Have you ever driven an EV?

Besides, in order to assess consumers perceptions about PHEVs, and hence determine potential differences between responses given considering BEVs, the following 4 additional items were included:

Construct (Approaching & Distancing)	**Items**
Environmental performance	Hybrid vehicles are more environmentally friendly when compared to combustion vehicles.
Driving Autonomy	Hybrid vehicles have sufficient electrical range for my use.
Maintenance cost reduction	Hybrid vehicle's maintenance is less expensive than combustion vehicle maintenance.
Purchasing price / governmental incentives / TCO	Hybrid vehicles have greater tax advantages in the purchasing process over combustion vehicles.

Within the scope of the study carried out, a test questionnaire was randomly distributed to 15 responses, as well as the realization and conduction of two test interviews. The data gathered from these tests were discarded from the final results and served only to ensure the correct comprehension of all designed statements.

Regarding the data analysis, different tools were used, targeting the different data gathering methods adopted. Quantitative results were studied using the Statistical Package for the Social Sciences (SPSS). This allowed the investigators to quantify and analyze trends in the text responses presented in surveys. On the other hand, the interviews were qualitatively analysed through a deductive approach using open coding (Burnard et al., 2008). Final results and conclusions are displayed in the upcoming section.

Chapter 4

Presentation and Analysis of Results

4.1 Qualitative Data Analysis

The main objective of conducting such an analysis was to examine the point of view of professional commercials operating in the sector under analysis, and hence verify:

i. Whether their perception of the proximity and distance factors currently influencing consumers purchasing decisions coincide with the responses later collected through the conducted primary research on consumers.

ii. If these professionals currently adopt different sales approaches to customers intending to purchase EVs versus ICEVs, namely by focusing on emphasizing EVs approaching attributes, and if so, which.

For its' qualitative analysis, scholars followed the steps recommended by Burnard et al., (2008). Through a deductive approach, the researchers analysed the interview transcripts based on the findings and central concepts collected from the literature review and hence highlighted and noted significant statements which provided evidence for and against their initial hypothesis. Such process was conducted using what the formerly mentioned authors term as "open coding". A summary of the initial coding framework for each of the four conducted interviews can be seen in table 3.

Table 3: Interviews initial coding framework

Interviewee	Interview Transcript	Initial Coding Framework
1. Sales Commercial at SOOCSANTOS Mercedes	*"[as a second car] An EV makes a lot of sense because we are not dependent on autonomy in emergency situations."*	**Driving autonomy**
	"[about PHEVs] Diesel cars already have a much lower maintenance cost than gasoline cars, and the addition to the electric one is the best option on the market."	**Maintenance cost reduction**
	"[about the process of selling EVs and ICEVs] It is basically the same thing. (...) a very critical point is to explain to customers that they will not be able to use the 450km of advertised autonomy."	**Driving autonomy** *No sales strategy differentiation
	"[about the process of selling EVs and ICEVs] At the time of delivery, we have to tell the customer (...) that at home it will take 8 hours to load, it is not easy."	**Time cost of charging**
	"[On the cost of batteries potentially being an objection from customers to EVs] Not at this point, because with the development and production of more batteries, the price has gone down."	**TCO**
	"Companies have benefits in buying cars with electrical components and this is very attractive for them."	**Governmental Incentives**
	"[On the future of EVs in competitive sports] The share of cars with these technologies in competition will increase, but for me, combustion racing will lose its essence. (…) One of the negative factors in this sense is the vehicles sound, without doubt. (…) the sound is fake and noticeable."	**Driving Experience** **Sound**
2. Sales Director at Mercedes	*"[About the process of selling EVs and ICEVs] There are noticeable differences between the sales strategy of EVs and ICEVs, since the argumentation in the EVs covers new areas such as batteries, electrical consumption, charging, and even*	**Battery life cycle** **TOC** **Time cost of charging** **Charging facilities availability** **Governmental incentives**

Interviewee	Interview Transcript	Initial Coding Framework
	accounting / taxation arguments since these vehicles have special taxation regimes / tax benefits."	
	"There are two main customer objections on BEVs, autonomy still limited which limit free mobility (the charging network is still reduced and takes a long time to charge) and the high cost of acquisition. For PHEVs the objections relate more to the future cost of replacing batteries."	**Driving autonomy** **Purchasing price** **TCO** (battery replacement)
	"[About EVs typical customer] Almost all companies. EVs have tax incentives to acquire by companies (VAT deduction) and reduced autonomous taxation, and only with more intensive use can the additional investment be made profitable compared to ICEVs, something that normally happens in professional use. "	**Governmental incentives**
3. Manager at Speedy Motorsport / Cartailor	*The emotions of the instant touch remain the same and without a doubt it is the most exciting factor of this technology.*	**Driving experience**
	"...autonomy is an obstacle and charging times are an equally great obstacle."	**Driving autonomy** **Time cost of charging**
	"I came to realize that there are different types of electric car customers. The "Pro-EVs" are not "Pro-automobiles". They are customers who do not appreciate the car for what it is, but for the energy efficiency and environmental benefits that it brings. As you must understand, these are customers who do not care about the small details of the car as a true motor lover and exclude the so-called "extra expenses", which is where we as a business are strong."	**Environmental Performance**
	"[about potential consumer objections to EVs] I don't believe the cost of batteries is a problem. As I usually say, you don't buy a combustion car thinking about the potential cost of an engine replacement. It goes the same with batteries and people get that."	**Battery life cycle**
	"There is a greater limitation besides autonomy and charging times, which are constantly being developed. The electric car	**Time cost of charging** **Driving autonomy**

Interviewee	Interview Transcript	Initial Coding Framework
	is not yet a highway car and I don't know if it ever will be."	
	"[On the future of EVs in competitive sports] I honestly think there's no fun in a race without noise and without the smell of gasoline."	**Driving Experience** **Sound**
4. Manager at Comval Racing	*"... the costs of using [an EV] are very low and one can have tax advantages when buying through the company."*	**TCO** **Environmental Performance**
	"There is future in sports competition for EVs, but this is different from saying that EVs are the future of competition. Combustion and racing go hand in hand, there is no other way. In technical terms EVs can become perfect, but the lack of noise will always take them away from competitions."	**Sound**
	The cost of technical preparation of an EV would be the same and perhaps the maintenance costs would be further reduced. But the same cannot be said for the cost of acquisition [of an EV compared to an ICEV]."	**Maintenance cost reduction** **Purchasing price**
5. e-Performance Manager at Porsche PT	*"[About the process of selling EVs and ICEVs being different] Yes, since an EV involves a new charging concept, we must add to its sales process an explanation of the ways of charging the vehicle and hence demonstrate such…"*	**Charging duration** **Charging facilities availability**
	"…Besides, it is natural that an EV customer needs to live the car experience and for that he needs to carry out his day to day to see if it adapts to his lifestyle."	**Driving experience**
	"The cars driving range autonomy is undoubtedly the point most mentioned by customers as being that carrying most doubts and objections.	**Driving autonomy**
	"If customers have very long journeys in their daily lives, with long distance travels, and a pace of life in which they are unable to stop at a service station to charge their car for 30 min, for example on a business	**Time cost of charging**

Interviewee	Interview Transcript	Initial Coding Framework
	trip, the second option always turns out to be the hybrid vehicle."	
	"[About EVs client] It is a customer mostly concerned with consumption and the effects on the environment. Besides, it is usually also a customer who buys his car through the company [for tax benefits]".	**Environmental performance** **Governmental incentives**
	"Hybrids are still an extremely valid option at the moment for those customers who need to travel a lot of kilometers and are not available to stop for car charging. *However, as electrification gains more and more strength and weight, we estimate that in 2021 a very significant increase in available quick chargers will facilitate this step and, in this way, the consumer will naturally become more confident in the purchase and use of these vehicles."*	**Time cost of charging**

* Note: These are initial coding frameworks corresponding to item ii) i.e., verifying if the professionals currently adopt different sales approaches to customers intending to purchase EVs versus ICEVs, and if so, which.

Following such acknowledgments, a final coding framework (Table 4) was designed. This disregards repeated items and hence groups each individual construct according to the three main ideas in assessment.

Table 4: Final coding framework

Final coding framework	Initial coding framework
EV's Purchase Approaching Factors	Environmental performance Maintenance cost reduction Governmental incentives Driving experience
EV's Purchase Distancing Factors	Driving autonomy Driving experience Sound Purchasing price TCO Time cost of charging
EV's Sales Approach Differentiation	Time cost of charging Battery life cycle TCO

Final coding framework	Initial coding framework
	Charging facilities availability Governmental incentives Driving experience

4.1.1 Qualitative Data Results

The fact that these individuals operate in distinct firms, with similar yet simultaneously distinctive roles, increases this data's reliability and predictive capability. Given such, results noticeably show that none of the four interviewed professionals considered and perceived that the battery life cycle and the controversial environmental performance of EVs were currently a main **distancing factor** for potential customers. In fact, while some mention that batteries have been getting cheaper, others argue that an EVs customer will not keep the vehicle for the time period requiring a battery replacement. Furthermore, the only environmental concern regarding EVs raised is precisely due to this fact, and the question arises while doubting where batteries that will be discarded in a few years and become obsolete will be listed. Even so, it is stated that this is not currently a factor of concern in the market and for its customers. for this reason, it is concluded that EVs battery life cycle and their potentially controversial environmental performance are not, at this point in time, harming potential sales by acting as distancing factors.

Regarding EVs purchase **approaching factors**, evidence portrays that comfort, social costs reduction, safety, fuel cost reduction and brand image were not mentioned by any of the four interviewed individuals. Furthermore, these individuals also missed out on these points when describing their EVs **sales strategy**. Besides, only one of the interviewed individuals mentioned that test-drives (i.e., the driving experience**)** are a key sales-method helping consumers understand whether or not EVs are suitable for their lifestyle. At last, fast chargers are seen as a critical approaching factor in the near future. It is suggested that these will take over distancing factors such as the time cost of charging, hence hoping to decrease this factor's currently divergent significance. Table 5 summarizes these findings.

Table 5: Qualitative analysis summary findings

	EV's Purchase Approaching Factors	EV's Purchase Distancing Factors	EV's Sales Approach Differentiation
Mentioned	Environmental performance	Driving autonomy	Time cost of charging
	Maintenance cost reduction	Driving experience	Battery life cycle
	Governmental incentives	Sound	TCO
	Driving experience	Purchasing price	Charging facilities availability
		TCO	Governmental incentives
		Time cost of charging	Driving experience
Missing	Fuel cost reduction	Controversial environmental performance	Fast chargers
	Brand	Depreciation	Driving experience
	Safety	Battery life cycle	Fuel cost reduction
	Comfort		Brand
	Social costs reduction		Safety
			Comfort
			Social costs reduction

4.2 Quantitative Data Analysis

Given such findings, the present investigation proceeded with the collection of quantifiable data from a total sample of 331 respondents. From these, only fully completed questionnaires were analysed, hence ensuring responses validity and reliability. In this sense, after rejecting incomplete questionnaire records, the final adjusted sample totalled 250 individuals.

Three initial customer portraying questions allowed a brief characterization of the individuals in the sample to be carried out, according to their consumer profile. As seen on Table 6 approximately 64% of respondents owned at least one EV. Besides, 85% claimed to have already driven an EV. Finally, 48% of these stated they were actively considering the purchase of an EV in the meantime.

Table 6: Sample's characteristics

EV	%	Non-EV	%	TOTAL
EV_Owner		**Non-EV_Owner**		
161	64%	89	36%	250
EV_Driver		**Non-EV_Driver**		
213	85%	37	15%	250
EV_PotentialC		**Non-EV_PotentialC**		
120	48%	130	52%	250

As the Shapiro-Wilk Test of Normality reported data's non-normal distribution (Table 7), further analysis was conducted using non-parametric tests. The results of the average tests performed are reported in the following section.

Table 7: Shapiro-Wilk Test of Normality

Constructs	Statistic	df	Sig.
EP	.663	250	.000
SD	.705	250	.000
CM	.840	250	.000
DE	.877	250	.000
DA	.792	250	.000
TCC	.838	250	.000
CFA	.795	250	.000
MCR	.781	250	.000
TAX_TCO	.732	250	.000
PH_EP	.858	250	.000
PH_DA	.893	250	.000
PH_MCR	.906	250	.000
PH_TAX_TCO	.903	250	.000
EV_OWNER	.606	250	.000
EV_DRIVER	.423	250	.000
EV_POTENTIALC	.636	250	.000

Note: non-normal distribution, all p-values bellow 0.05 threshold.

Regarding the data's reliability, this study analysed the questionnaire's 13 designed item's Cronbach's Alpha coefficient (Taber, 2018). The Cronbach's Alpha value of .70 (Appendix A) suggests the 13 tested item's relatively high internal consistency.

4.2.1 Quantitative Data Results

Quantitative data was first subject to a descriptive statistics analysis (Table 8). The highest mean score, suggesting the greatest concordance amongst respondents, was for the **Environmental Performance** construct (M = 4.59; SD = .616), followed by the **TCO and Government tax incentives** construct (M = 4.32; SD = .893). Opposingly, the lowest mean result was for the **Charging facilities availability** (M = 2.24; SD = 1.029) followed by **Time cost of charging** (M = 3.63; SD = 1.120). The greatest variation in agreement between the sample's responses was found for the **Sound** factor (Var = 1.406) and the lowest discordance for the **Environmental Performance** (Var = .380). Furthermore, no one from the studied sample rated "Totally disagree" for the Environmental Performance item regarding BEVs. However, when asked about PHEVs specifically, some did.

Table 8: Descriptive statistics

Constructs	Minimum	Maximum	Mean	Std. Deviation	Variance
EP	2	5	4.59	.616	.380
SD	1	5	4.19	1.186	1.406
CM	1	5	3.89	1.006	1.012
DE	1	5	3.71	1.119	1.252
DA	1	5	3.94	1.109	1.229
TCC	1	5	3.63	1.120	1.255
CFA	1	5	2.24	1.029	1.059
MCR	1	5	4.22	.922	.849
TAX_TCO	1	5	4.32	.893	.797
PH_EP	1	5	3.70	1.090	1.189
PH_DA	1	5	3.13	1.245	1.550
PH_MCR	1	5	2.88	1.181	1.394
PH_TAX_TCO	1	5	3.38	1.074	1.153

When ordinally grouping the 9 items corresponding to EVs, we conclude on the most likely to be Approaching and Distancing factors (Table 9). Hence, the Environmental Performance (EP), Governmental Tax incentives and TCO (TAX_TCO) and the Maintenance cost reduction (MCR) attributes of EVs are predicted to be the greatest consumption approaching factors. On the other hand, the Charging facilities availability (CFA), the Time cost of charging and the Driving experience (DE) are suggested as the attributes most distancing consumers from a purchase.

Table 9: EV items ordered by mean response result

Constructs	Mean	Spectrum
1. EP	4.59	Approaching Factors
2. TAX_TCO	4.32	
3. MCR	4.22	
4. SD	4.19	
5. DA	3.94	
6. CM	3.89	
7. DE	3.71	
8. TCC	3.63	
9. CFA	2.24	Distancing Factors

Given existing evidence highlighted by the qualitative analysis regarding the distinction between BEVs and PHEVs, the same assessment was done on the 4 items rating specifical elements regarding PHEVs (Table 10). This time, results were compared with those attributed to the same construct regarding BEVs.

As may be seen, individuals perceive higher benefits over BEVs than hybrid vehicles. For example, the maintenance cost reduction (MCR) construct which was classified as the third best approaching factor for BEVs with a mean response of 4.22, portrayed a mean response of 2.88 regarding PHEVs. This suggests that when asked to rate the statement "Hybrid vehicle's maintenance is less expensive than combustion vehicle maintenance.", on average, individuals perceived that the maintenance cost reduction benefit is greater for fully EVs than for plug-in hybrid ones. It could hence be concluded that some individuals perceive this as a consumption distancing factor for PHEVs whilst considering it as an approaching factor for BEVs.

Table 10: PHEV items ordered by mean response result

PHEV Constructs	Mean	BEV Constructs	Mean
1. PH_EP	3.70	1. EP	4.59
2. PH_TAX_TCO	3.38	2. TAX_TCO	4.32
3. PH_DA	3.13	5. DA	3.94
4. PH_MCR	2.88	3. MCR	4.22

Furthermore, non-parametric tests were conducted aiming to verify potential significant differences between average responses and consumer types. For instance, this investigation considered it would be particularly important to verify, for each construct, if there are significant differences between average responses for EV car owners versus non-EV car owners (Table 11). Hence, determining whether ownership demystifies some pre-conceived ideas.

Table 11: EV constructs Mann-Whitney U test (grouping variable EV_Owner)

Constructs	EP	SD	CM	DE	DA	TCC	CFA	MCR	TAX_TCO
Statistics	6,337.000	5,222.000	5,130.000	5,695.000	5,210.500	4,919.000	6,077.500	6,137.500	5,059.000
Z	-1.808	-3.983	-3.908	-2.785	-3.819	-4.384	-2.195	-2.035	-4.254
P-value	.071	.000 *	.000 *	.005 *	.000 *	.000 *	.028 *	.042 *	.000 *

Note: Grouping Variable: EV_OWNER
* p value bellow 0.05 threshold

Results suggest that only one construct did not reveal statistically significant differences amongst the two response groups (EV owner vs. Non-EV owner). Such was the case for the Environmental Performance construct ($p = .071$; $p > .05$), suggesting that despite possessing an EV's ownership or not, individuals agree with placing it as a purchasing Approaching factor.

Concerning the same test on PHEVs constructs, driving autonomy (DA) was the only statistically different mean result between EV owners and the antonym group ($p = .015$; $p < .05$). To further conclude on the meaning of such differences, mean values for each significantly different construct were plotted, according to the grouping variable to which they belong (Table 12).

Table 12: Mean scores with grouping variable EV_OWNER

Sample Category	SD	CM	DE	DA	TCC	CFA	MCR	TAX_TCO	PH_DA
EV owner (n = 161)									
Mean	4.37	4.07	3.83	4.12	3.86	2.32	4.30	4.53	2.99
Std. Deviation	1.122	.963	1.158	1.035	1.015	1.004	.895	.623	1.250
Non-EV owner (n = 89)									
Mean	3.87	3.57	3.48	3.61	3.20	2.09	4.08	3.93	3.38
Std. Deviation	1.236	1.010	1.013	1.164	1.179	1.062	.956	1.146	1.201

It is hence suggested that, on average, EV owners' value more each of the constructs than non-EV owners. The exception comes when questioning the sample regarding PHEVs, whereby non-EV owners generally rate PHEVs driving autonomy higher that currently EV owners. Such findings could hence suggest that ownership reports a different (lower) reality regarding the autonomy of plug-in hybrid vehicles. This is so as the findings suggest non-EV owners perceive greater autonomy for PHEVS that users who currently own an EV.

Moreover, this study verified, for each construct, if there are significant differences between average responses for individuals who have driven an EV and those who haven't (Table 13). Such an analysis proved particularly relevant as it aimed to verify the effects of test-driving experiences and hence validate whether these should be considered a vital process within EV sales strategy approach. It is, therefore, important to note that the driving experience was only mentioned by one of the five professionals interviewed as a factor of approximation typically focused upon during EVs sales strategy.

Table 13: EV constructs Mann-Whitney U test (grouping variable EV_Driver)

Construct	EP	SD	CM	DE	DA	TCC	CFA	MCR	TAX_TCO
Statistics	3,744.5 00	3,492.0 00	3,088.0 00	2,960.0 00	3,389.0 00	3,043.0 00	3,583.0 00	3,128. 500	1,985. 500
Z	-.577	-1.240	-2.208	-2.506	-1.453	-2.363	-.974	-2.170	-5.326
P-value	.564	.215	.027	.012	.146	.018	.330	.030	.000

Note: Grouping Variable: EV_DRIVER

* p value bellow 0.05 threshold

Results predict that, on average, consumers who have driven an EV before statistically differ in their mean response for the constructs of Comfort (CM), Driving experience (DE), Total charging cost (TCC), Maintenance cost reduction (MCR) and Government tax incentives and TCO (TAX_TCO). Regarding PHEVs, consumers who have had the opportunity to drive an EV statistically differ in average response for the Government tax incentives and TCO (TAX_TCO) construct ($p = .002$; $p < .05$).

To further conclude on the meaning of such differences, mean values for each significantly different construct were plotted, according to the grouping variable to which they belong (Table 14).

Table 14: Mean scores with grouping variable EV_DRIVER

Sample Category	CM	DE	TCC	MCR	TAX_TCO	PH_TAX_TCO
EV Driver (n = 213)						
Mean	3.93	3.77	3.69	4.28	4.46	3.47
Std. Deviation	1.035	1.136	1.123	.897	.755	1.066
Non-EV Driver (n = 37)						
Mean	3.65	3.35	3.27	3.92	3.51	2.89
Std. Deviation	.789	.949	1.045	1.010	1.170	.994

Mean results for all constructs were higher for consumers who had driven EV in the past. This highlights the positive impact of test-drives on consumers and predicts its beneficial effect if considered an essential step during EVs sales strategy.

Finally, the last non-parametric analysis performed intended to verify, for each construct, if there are significant differences between average responses for individuals who are considering buying an EC in the near future and those who aren’t. This would help understand, whether or not, these are specific consumers who value certain attributes more than others.

Interestingly, the Mann-Whitney U test performed only revealed a statistically significant difference for the Environmental Performance construct (EP) ($p = .002$; $p < .05$). By comparing the mean values for this construct according to the grouping variable EV_POTENTIALC, findings support the assumption formerly verified that consumers who are considering purchasing an EV, on average, value environmental performance more than those who aren't considering such purchase. No other significant differences for the remaining constructs were registered.

Chapter 5

Discussion and Conclusions

From such an analysis, this paper concludes on key takeaways for companies which together work towards a greater EV sales success rate, EV customer's satisfaction and increase in demand.

As a central idea, this investigation highlights the importance of EVs Environmental Performance (EV) in consumers purchasing decision. In fact, not only was this, on average, the attribute most value by the study's sample (M = 4.59; SD = .616), it was also the one to which responses varied the least (Var = .380; Min. = 2). Knowing so, should allow firms to focus sales and marketing strategies on vehicles EP attributes, aiming to hence target exactly what consumers consider as buying approaching factors.

Interestingly, EP was also the one factor which did not reveal significant differences when grouping individuals according to EV's ownership and driving experience, meaning that despite owning an EV or not, or having driven one or not, on average, all respondents valued this construct similarly.

However, when grouping results by individuals currently thinking about pursuing an EV in the near future, quantitative findings support the assumption verified during the conducted interviews, that consumers who are considering purchasing an EV, on average, value environmental performance more than others. From such, the importance of tailoring marketing and sales strategies and addressing this attribute is once again emphasized.

Furthermore, the present work goes further and provides evidence portraying that constructs previously identified by existing literature, such as Comfort (CM), Social costs reduction (SCR), Safety (SF), Fuel cost reduction (FCR) and Brand image (BI) are not typically mentioned by professionals within the sector. Them being previously studied concepts with proven relevance on customers point of view, it would be deductible that they would be addressed and approached by sales teams and advertising campaigns.

Furthermore, other conclusions were drawn particularly concerning the significance of test-driving experiences and EVs. In fact, mean results for all statistically significant constructs were higher for consumers who had driven EVs in the past. Test drives should hence be approached during EVs sales process as had been suggested by one of the interviewed professionals (Interview 5) as customers manage to assess whether or not the vehicle suits their daily life routines and hence demystifies pre-conceived ideas that these are unsuitable and have no sufficient autonomy.

Moreover, findings also suggest that non-EV owners perceive greater autonomy for PHEVS than users who currently own an EV. From such, firms should realize the importance of clarifying any and all doubts of customers and hence, once again, allow them to test the vehicles before purchase. Only this way will clients purchase suitable vehicles without being misled. Disappointed customers are likely to proliferate negative word of mouth on behalf of EVs and hence distance potential buyers from purchasing such vehicles.

Chapter 6

Limitations and Future Works

The present investigation focused in solely addressing constructs highlighted during the conducted interviews. In this sense, other constructs which literature has suggested to be significant, were disregarded. Given such, future research should focus in quantitatively assessing consumers responses for a wider range of EVs attributes than those hereby examined.

Furthermore, the studies so far reviewed, and the present investigation conducted have failed to consider the effects of newer business models such as the leasing of batteries. For instance, such possibilities could play a significant role in influencing consumers responses for TCO and Battery life cycle (BLC) constructs. It is hence suggested that following works address these possibilities and the effect of customers decisions.

Finally, this investigation should be replicated on a greater and more geographically dispersed sample in order to guarantee results generalizability and validity.

Overall, the work here developed has provided measurable conclusions as to consumers purchase approaching and distancing factors, with regards to EVs as well as key contributions regarding key elements to introduce and emphasize during sales and marketing strategies.

Appendix A: Reliability and internal consistency coefficient

Reliability Statistics	
Cronbach's Alpha	.700

References

AG, P. (2020). *Porsche Taycan*. https://www.porsche.com/countries/taycan-sound/?cslang=en

Bickert, S., Kampker, A., & Greger, D. (2015). Developments of CO2-emissions and costs for small electric and combustion engine vehicles in Germany. *Transportation Research Part D: Transport and Environment*, *36*, 138–151. https://doi.org/10.1016/j.trd.2015.02.004

Burnard, P., Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Analysing and presenting qualitative data. *British Dental Journal*. https://doi.org/10.1038/sj.bdj.2008.292

Cazzola, P. (2018). Global EV Outlook 2018. *Global EV Outlook 2018*. https://doi.org/10.1787/9789264302365-en

Cecere, G., Corrocher, N., & Guerzoni, M. (2018). Price or performance? A probabilistic choice analysis of the intention to buy electric vehicles in European countries. *Energy Policy*, *118*(June 2017), 19–32. https://doi.org/10.1016/j.enpol.2018.03.034

Danielis, R., Giansoldati, M., & Rotaris, L. (2018). A probabilistic total cost of ownership model to evaluate the current and future prospects of electric cars uptake in Italy. *Energy Policy*, *119*(April), 268–281. https://doi.org/10.1016/j.enpol.2018.04.024

Degirmenci, K., & Breitner, M. H. (2017). Consumer purchase intentions for electric vehicles: Is green more important than price and range? *Transportation Research Part D: Transport and Environment*. https://doi.org/10.1016/j.trd.2017.01.001

Delucchi, M. A., & Lipman, T. E. (2001). An analysis of the retail and lifecycle cost of battery-powered electric vehicles. *Transportation Research Part D: Transport and Environment*, *6*(6), 371–404. https://doi.org/10.1016/S1361-9209(00)00031-6

Deng, X. (2020). *The development of EV and its impact on energy , environment and other socioeconomic aspects*. *20*, 975–982. https://doi.org/10.12720/sgce.9.6.975-982

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*.

https://doi.org/10.1016/j.enpol.2012.06.009

Enneking, U., Neumann, C., & Henneberg, S. (2007). How important intrinsic and extrinsic product attributes affect purchase decision. *Food Quality and Preference*, *18*(1), 133–138. https://doi.org/10.1016/j.foodqual.2005.09.008

Evtimov, I., Ivanov, R., & Sapundjiev, M. (2017). Energy consumption of auxiliary systems of electric cars. *MATEC Web of Conferences*, *133*, 2–6. https://doi.org/10.1051/matecconf/201713306002

Facts, W. (n.d.). *WLTP Facts*. https://www.wltpfacts.eu/

Gómez Vilchez, J., Harrison, G., Kelleher, L., Smyth, A., & Thiel, C. (2017). Quantifying the factors influencing people's car type choices in Europe: Results of a stated preference survey. In *JRC science for policy report. Joint Research Centre (JRC), European Commission*. https://doi.org/10.2760/98060

Harrison, G., & Thiel, C. (2017). An exploratory policy analysis of electric vehicle sales competition and sensitivity to infrastructure in Europe. *Technological Forecasting and Social Change*, *114*, 165–178. https://doi.org/10.1016/j.techfore.2016.08.007

Hastings, A., Pollard, J. K., Garay-Vega, L., Stearns, M. D., & Guthy, C. (2011). Quieter Cars and the Safety of Blind Pedestrians, Phase 2: Development of Potential Specifications for Vehicle Countermeasure Sounds Final Report. *National Highway Transportation Safety Agency*, *October*, 21, 27.

Iora, P., & Tribioli, L. (2019). Effect of ambient temperature on electric vehicles' energy consumption and range: Model definition and sensitivity analysis based on Nissan Leaf data. *World Electric Vehicle Journal*, *10*(1), 1–15. https://doi.org/10.3390/wevj10010002

Jensen, A. F., & Mabit, S. L. (2017). The use of electric vehicles: A case study on adding an electric car to a household. *Transportation Research Part A: Policy and Practice*, *106*(September), 89–99. https://doi.org/10.1016/j.tra.2017.09.004

Kim, T. G., Lee, S. K., & Lee, H. H. (2009). Characterization and quantification of luxury sound quality in premium-class passenger cars. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, *223*(3), 343–353. https://doi.org/10.1243/09544070JAUTO989

Kostyra, D. S., Reiner, J., Natter, M., & Klapper, D. (2016). Decomposing the effects of online customer reviews on brand, price, and product attributes. *International Journal of Research in Marketing*, *33*(1), 11–26. https://doi.org/10.1016/j.ijresmar.2014.12.004

Lawder, M. T., Northrop, P. W. C., & Subramanian, V. R. (2014). Model-Based SEI Layer Growth and Capacity Fade Analysis for EV and PHEV Batteries and Drive Cycles. *Journal of The Electrochemical Society*, *161*(14), A2099–A2108. https://doi.org/10.1149/2.1161412jes

LEE, T. Y. K. and S. H. (2012). Combustion and Emission Characteristics of Wood Pyrolysis Oil-Butanol Blended Fuels in a Di Diesel Engine. *International Journal of …*, *13*(2), 293–300. https://doi.org/10.1007/s12239

Lombardi, L., Tribioli, L., Cozzolino, R., & Bella, G. (2017). Comparative environmental assessment of conventional, electric, hybrid, and fuel cell powertrains based on LCA. *International Journal of Life Cycle Assessment*, *22*(12), 1989–2006. https://doi.org/10.1007/s11367-017-1294-y

Morrissey, P., Weldon, P., & O'Mahony, M. (2016). Future standard and fast charging infrastructure planning: An analysis of electric vehicle charging behaviour. *Energy Policy*, *89*(2016), 257–270. https://doi.org/10.1016/j.enpol.2015.12.001

Painter, D. S. (2017). *Oil and Geopolitics : The Oil Crises of the 1970s and the Cold War Author (s): David S . Painter Source : Historical Social Research / Historische Sozialforschung , Vol . 39 , No . 4 (150), Special Issue : The Energy Crises of the 1970s : Anticipation*. *39*(4), 186–208.

Parizet, E., Robart, R., Chamard, J. C., Schlittenlacher, J., Pondrom, P., Ellermeier, W., Biancardi, F., Janssens, K., Speed-Andrews, P., Cockram, J., & Hatton, G. (2013). Detectability and annoyance of warning sounds for electric vehicles. *Proceedings of Meetings on Acoustics*, *19*. https://doi.org/10.1121/1.4800182

Pavlovic, J., Marotta, A., & Ciuffo, B. (2016). CO2 emissions and energy demands of vehicles tested under the NEDC and the new WLTP type approval test procedures. *Applied Energy*, *177*(2016), 661–670. https://doi.org/10.1016/j.apenergy.2016.05.110

Sataloff, R. T., Johns, M. M., & Kost, K. M. (2018). *No 主観的健康感を中心とした在宅高齢者における 健康関連指標に関する共分散構造分析Title*.

Sun, X. H., Yamamoto, T., & Morikawa, T. (2015). Charge timing choice behavior of battery electric vehicle users. *Transportation Research Part D: Transport and Environment*, *37*, 97–107. https://doi.org/10.1016/j.trd.2015.04.007

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*. https://doi.org/10.1007/s11165-016-9602-2

Teixeira, A. C. R., & Sodré, J. R. (2018). Impacts of replacement of engine powered vehicles by electric vehicles on energy consumption and CO2 emissions. *Transportation Research Part D: Transport and Environment*, *59*(February), 375–384. https://doi.org/10.1016/j.trd.2018.01.004

TIAGO ISIDRO DA COSTA. (2014). Veículo, Estratégia De Localização Dos Postos De Carregamento Para O Elétrico O Caso Da Cidade Do Porto. *Dissertação De Mestrado*, 119.

Tu, J. C., & Yang, C. (2019). Key factors influencing consumers' purchase of electric vehicles. *Sustainability (Switzerland)*, *11*(14). https://doi.org/10.3390/su11143863

Veziroglu, A., & MacArio, R. (2011). Fuel cell vehicles: State of the art with economic and environmental concerns. *International Journal of Hydrogen Energy*, *36*(1), 25–43. https://doi.org/10.1016/j.ijhydene.2010.08.145

Vilchez, J. J. G., Smyth, A., Kelleher, L., Lu, H., Rohr, C., Harrison, G., & Thiel, C. (2019). Electric car purchase price as a factor determining consumers' choice and their views on incentives in Europe. *Sustainability (Switzerland)*, *11*(22), 1–14. https://doi.org/10.3390/su11226357

Weldon, P., Morrissey, P., & O'Mahony, M. (2018). Long-term cost of ownership comparative analysis between electric vehicles and internal combustion engine vehicles. *Sustainable Cities and Society*, *39*(March), 578–591. https://doi.org/10.1016/j.scs.2018.02.024

Zarazua de Rubens, G. (2019). Who will buy electric vehicles after early adopters? Using machine learning to identify the electric vehicle mainstream market. *Energy*, *172*, 243–254. https://doi.org/10.1016/j.energy.2019.01.114

Zhang, X., Xie, J., Rao, R., & Liang, Y. (2014). Policy incentives for the adoption of electric vehicles across countries. *Sustainability (Switzerland)*, *6*(11), 8056–8078.

https://doi.org/10.3390/su6118056