Elaboration of perceptual maps to support the strategic positioning of alternative fuel vehicles

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Abstract: The constant introduction of new technologies in an even more competitive market in which communication with the consumer plays an increasingly key role forces companies to study how consumers perceive their products in relation to the competition. The positioning of brands and products is becoming increasingly important to achieve a differentiated place in the consumer's mind and to make them prefer a product or service over the competition. The perceptual maps allow this positioning to be visualized in a simple and accessible way, ideal for having a global vision of the different market players and for making strategic marketing decisions. Although some studies in the literature have been dedicated to issues related to consumer behavior towards alternative fuel vehicles, none has addressed their positioning yet. This research aims to contribute to the literature by studying the positioning of alternative fuel vehicles in the Portuguese market using the perceptual maps tool, which has proven to be especially useful in supporting strategic decision making. The data for this study were obtained through a survey and the factor analysis methodology was applied in order to establish the main perceptual dimensions of alternative fuel vehicles based on their attributes. The results show that the most important perceptual dimensions are "Safety" and "Performance", and that the electric vehicles are the best positioned in the this first dimension and the fuel-cell vehicles in the second one.

Keywords: Perceptual Maps, Positioning, Factor Analysis, Alternative Fuel Vehicles

1. Introduction

Humanity is facing the reality of climate change. Climate change is driven by the excessive emission of greenhouse gases (GHG) responsible for the increase in the earth's temperature. Carbon dioxide (CO2) emissions from fossil fuel combustion contributed with approximately 78% of the total increase in GHG emissions between 1970 and 2010 (Pachauri et al., 2014). Transports account for about one-fifth of global CO2 emissions. Of these, almost half are caused by passenger vehicles (IEA, 2022).

Governments in most countries have been promoting the efficient use of energy and reducing reliance on fossil fuels to minimize harmful emissions. The introduction of alternative energy solutions to overcome these issues is therefore imperative. In the automotive sector, alternative technologies have emerged and their introduction in the market has been increasing (Duarte et al., 2016). These alternative fuel vehicles (AFV) emerge as a good solution to reduce GHG emissions and dependence on fossil fuels, as they are energy efficient, and their emission of pollutants is lower compared to vehicles with an internal combustion engine (ICV). In the year 2014, the number of AFV sold in the European Union (EU) represented only 4% of total vehicle sales and in 2020 this number rose to 24% (ACEA, 2020). However, this market share is still much lower than that of petrol or diesel vehicles. One perspective on these modest numbers is that the purchase of AFV is very much conditioned by the not so positive perception that consumers still have of them, particularly regarding their technical potential (Schuitema et al., 2013). Thus, it is important to understand how consumers perceive AFV in relation to this or other relevant dimensions (Rezvani et al., 2015). This relationship between the purchase of an AFV and consumer perception according to certain attributes is advocated by Skippon & Garwood (2011) and Graham-Rowe et al. (2012). In a market with so much growth potential and environmental impact it is of high importance for economic decision-makers to understand how distinct types of vehicles are positioned according to the criteria that consumers weigh at the time of purchase.

With all this in mind, the aim of this study is to present in a clear and accessible way - using the perceptual maps technique - how the distinct types of AFV existing in the Portuguese market are positioned according to consumer perceptions of their attributes. These perceptual maps allow to support the strategic positioning of products already on the market as well as potential new competitors, contributing to the development of a market with strong positive implications on environmental and energy transition issues.

2. Problem Definition

AFV are typically defined as those vehicles designed to run on at least one fuel other than gasoline or diesel, or at least partially on electricity. Examples of alternative fuels are electricity, hydrogen, natural or propane gas, biodiesel, ethanol, or methanol (U.S. Department of Energy, 2021). Electric vehicles (EV) have an electric motor that works thanks to energy stored in batteries. They include vehicles with different technologies, such as hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV) or battery electric vehicles (BEV). An HEV has an internal combustion engine and an electric motor driven by a battery. The battery is charged by recovering energy that would be lost during braking or directly by the internal combustion engine. PHEVs are based on the same power system as HEVs but have batteries with improved capacities and the possibility to be charged by connecting the vehicle to the grid. A PHEV can run on a combustion engine or on an electric motor. BEV run exclusively on electric propulsion. The engine is powered by a battery that is charged by connecting it to the external power grid (Rezvani et al., 2015). Hydrogen vehicles have electric engines in which electricity is generated through fuel cells and are called fuel-cell vehicles (FCV). The process of obtaining hydrogen is based on the electrolysis of water (Yavuz et al., 2015). Natural gas and propane (LPG) are fossil fuels although they are considered alternative fuels. Compared to diesel/gasoline vehicles, these vehicles emit lower levels of particulate and toxic gases into the air (Goyal, 2003). Biofuels are alternative fuels whose production can be derived from biomass and agricultural waste. Among them are biodiesel, ethanol and methanol and vehicles that use them are called biofuel vehicles (BV) (Erdiwansyah et al., 2019).

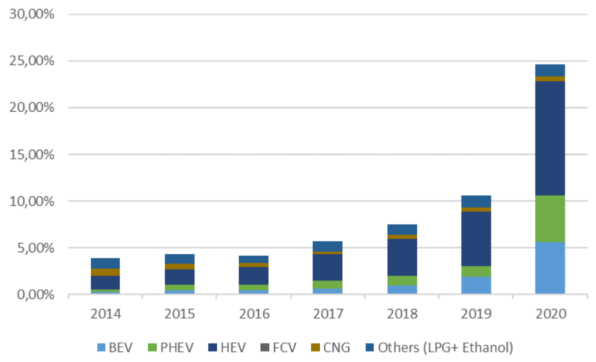

Figure 1 - Market share of new cars registered in the EU by fuel type (ACEA, 2020)

In recent years, the adoption of BEV has seen an increasing trend. HEV have achieved the highest market share in the EU followed by BEV and PHEV. FCV sales have almost tripled from 2018 to 2020, however, they still represent a small share of the total market share (0.01%). Gas and biofuel vehicles, meanwhile, have kept sales numbers steady over the past few years (Figure 1). The numbers of new registrations show that although AFV are seen as promising technologies, and despite the large growth in recent years, they have had some difficulty in penetrating the markets compared to ICV. It is therefore quite important to understand consumers' perceptions and preferences and to understand what motives and incentives would encourage them to adopt AFV. This information could become a valuable aid for industry players' strategies and for developing targeted support policies (Potoglou & Kanaroglou, 2007).

3. Literature Review

3.1. Positioning

Positioning refers to the way consumers perceive products or services present in a certain market in relation to the competition (D. J. Kim et al., 2007). Through positioning brands try to build in the consumer's mind a competitive advantage in terms of the attributes of the product or service they provide. The product positioning is a key element in the strategy of a company in which each brand or product tries to occupy a differentiated position in the customer's perceptual space. For a good positioning it is necessary to identify the decision criteria used by the consumer to evaluate different offers and to develop and communicate that positioning (Lendrevie et al., 2015). The position that a product occupies in the consumer's mind, i.e., the perception they have of it, is central to the choice between competing products (Vigar-Ellis et al., 2009).

3.2. Perceptual Maps and methodologies

Perceptual maps are an analytical tool often used in marketing research to support positioning decisions. These maps are visual representations of consumers' perceptions of competing products or services. They provide images of how these are situated in the market according to various perceptual dimensions (Kotler & Keller, 2016). They are useful when positioning or repositioning an offer or evaluating the positioning over time according to the existing competition. In addition, they can show unfilled gaps in the market and the weaknesses or strengths of competitive offers (C. M. F. Monteiro et al., 2010). According to Kohli and Leuthesser (1993), marketers usually have two objectives in mind when using perceptual maps: to determine where a given product/brand is in relation to the competition and to identify the attributes that are determinant in influencing consumer choice in each product category. The determining attributes are those to which customers give greater importance and which, at the same time, differentiate the product because if there are no differences this attribute will not be influential in decision making.

The analytical techniques for the development of perceptual maps can be classified into two types: decompositional methods and compositional methods (Hair, 2009). In the decompositional methods we find multidimensional scaling (MDS) and examples of composition methods are factor analysis (FA) and discriminant analysis. Decompositional methods assume that consumers have a holistic perception of products that cannot be decomposed. Compositional methods, on the other hand, use attributes defined in the research phase that are rated by consumers on multidimensional scales. Compositional methods (attribute-based) achieve more direct measures of perceptions than decompositional methods (based on similarity judgements) but can be incomplete if attribute ratings are not properly developed. They have the limitation that attributes come pre-determined by the research and do not come from the respondent himself. On the other hand, similarity techniques are limited by the number of products under study because at least seven or eight products are needed to obtain maps with two to three dimensions. In the case of attribute-based techniques, there are no such restrictions, which favors these techniques if the number of products is small (Keon, 1983).

Factor analysis is a technique which allows the initial set of attributes to be reduced to a smaller set of dimensions called factors. These dimensions are based on the variance and correlation between the attributes (Gwin & Gwin, 2003). Once the factors are identified, the product/service rankings in these dimensions are used to position them on the perceptual map (Kohli & Leuthesser, 1993). This technique allows for easy insight into how products are positioned in relation to their attributes. According to Hauser & Koppelman (1979) factor analysis can be considered superior to other methods for measuring consumer perceptions when: the number of products is relatively small (seven or less), there are variations in the way consumers perceive products within the same category and it was possible to identify a set of attributes likely to represent the product category during the research phase.

To make the study of the positioning through the FA more complete some studies apply other complementary techniques that aim to address the importance of the attributes. Thus, in the studies of Jorge & Monteiro (2011) and C. M. F. Monteiro et al. (2010) the authors consider the use of the technique of Multiple Regression Analysis (MRA) to identify the relative importance of each main perceptual dimension obtained.

3.3. Attributes of AFV

There are in the literature some studies related to the positioning of vehicles, but regarding AFV, no study was found that reflects the positioning of the different existing offers according to consumers' perceptions. However, there are several studies that focus on consumer preferences in relation to AFV. These studies allow to understand which are the most important attributes of a product according to consumer preferences and even draw conclusions about consumer segmentation as is the case of studies by Hackbarth & Madlener (2013) and Ziegler (2012). However, they are not able to reveal the positioning of the different competitors according to the consumers' perception. Based on the literature review of preference studies, attempts were made to identify the attributes of AFV considered most relevant for consumers. The literature results show distinct groups of attributes among them financial, technical, public policy and infrastructure, environmental and safety attributes. The attributes considered most relevant are those related to financial attributes and technical attributes (Hackbarth & Madlener, 2013; Koetse & Hoen, 2014; Liao et al., 2017). Studies that consider security attributes highlight their high importance in consumer preferences and purchase intentions as is the case in Li et al. (2017) and Kowalska-Pyzalska et al. (2022). On the contrary, policy-related attributes are generally considered less relevant (Koetse & Hoen, 2014).

4. Methodology

Vehicles selection: To achieve a complete analysis of the AFV sector, one BEV, one PHEV, one HEV, one FCV and one LPG (representing natural gas and propane vehicles) will be submitted to analysis. BV will not be considered in the study given their low market share and the fact that they are not necessarily differentiating factors in determining the vehicle typology since biofuels can be used in ICV. The study will also include an ICV (representing gasoline and diesel vehicles) in order to be able to compare the positioning of AFV with conventional vehicles. Since this study aims to study the positioning of the different products without considering the brand, no information will be shared with respondents regarding this aspect.

Segmentation: Perceptions and preferences towards different types of vehicles differ among consumers and therefore individual-related variables that introduce a certain heterogeneity should be considered. These variables may be related to socio-economic status, psychological factors, geography, or mobility patterns (Liao et al., 2017). The reviewed studies do not present a homogeneity when it comes to the segmentation criteria of AFV consumers. However, since age and level of education/income emerge as possible indicators of a higher propensity to purchase AFV the study will pay special attention to the segment of people under 35 years of age and level of education equal to or higher than university education. Thus, following the example of Oliveira et al. (2015) the participants of the study should meet the following criteria: be potential buyers of a vehicle, be aged over 18 and reside in Portugal. The restriction to the national market was motivated by a greater ease of access to primary data collection with Portuguese consumers versus foreign consumers. In addition, financial attributes, infrastructure attributes and public policy attributes may vary considerably across regions, and it was deemed more prudent to restrict the study to the national level in order to minimize large variances in these attributes.

Attribute selection: The attributes included in the study were taken from the studies on consumer behavior towards traditional and alternative fuel vehicles found in the literature. Once the attributes are defined, it is important to review them with potential consumers to see if the list of variables includes the main characteristics and concerns of consumers about AFV, through interviews. These can be done individually or in groups, in so-called focus groups, which allow an exchange of impressions and discussion among the various participants on the attributes of the AFV (Rekettye & Liu, 2001).

Focus Group: Focus groups are a carefully planned series of discussions designed to gain insights on a particular subject in an environment where participants feel comfortable discussing and sharing their opinions. Focus groups are seen as an effective exploratory approach to gathering data on the attributes most valued by consumers as they allow for the creation of an environment where participants are free to share their thoughts and opinions, rather than choosing narrow a priori answers (Krueger, 2014).

Reducing the list of attributes: Once the attributes are collected based on the literature and the discussions with consumers through the focus group it may arise the need to reduce the list of attributes to make the future data collection less dense and thereby increase the likelihood of getting responses (Jorge & Monteiro; 2011). Based on these studies, a first questionnaire is conducted where respondents are asked to rate each attribute using a 7-point Likert scale of importance. The sampling technique is the non-probabilistic convenience technique characterized by the researcher's confidence in choosing the right people in a random universe, meeting the segmentation requirements imposed by the research. Convenience sampling is easier to apply, has lower costs, and is less time-consuming than other sampling techniques (Malhotra et al., 2017).

Data collection - Perceptions questionnaire: Following the example of the studies reviewed on positioning, this study will use primary data as a source of information on consumer perceptions collected through a questionnaire. Also in this survey, we chose to use the non-probabilistic convenience sampling technique.

Factor Analysis: To build the positioning maps we will use the FA since, according to the literature review, it is the most robust technique when the number of products is relatively small, there may be variations in how consumers perceive the products, and it is possible to identify a set of attributes likely to represent the product category during the research phase. However, these three conditions are met in this study and are explained above: number of products below seven (BEV, HEV, PHEV, FCV, LPG and ICV); the presence of heterogeneity in the attributes of the different objects of study; the existence of a set of attributes identified in the literature and representative of the AFV. Factor analysis aims at reducing the number of initial attributes by identifying a smaller set of dimensions or factors which, in turn, are associated with a set of highly correlated original variables (del Campo et al., 2008). The perceptual maps are built based on these dimensions (each axis corresponding to a different dimension), and the positioning of the different objects are represented by their mean factor score in each dimension/factor (Jorge & Monteiro, 2011). In FA, the first step consists in checking whether the data set is adequate. Regarding the sample size, it should contain more than 100 participants and the ratio of sample per variable should be greater than 5:1 (Ford et al., 1986). The correlation matrix of the variables should also be analyzed to check if they are sufficiently correlated to be subject to study (all variables should have at least one correlation coefficient greater than 0.3 (Hair, 2009)). Bartlett's test, which evaluates the hypothesis that the correlation matrix is an identity matrix in which the correlations are all equal to zero, should have a significance level below 0.05 (Hair, 2009). The Kaiser-Meyer-Olkin (KMO) criterion, on the other hand, must be greater than 0.5 to perform FA (Williams et al., 2010). The second step is to define the method of extraction of the factors as well as the number of factors to be extracted. The most used method is Principal Component Analysis (PCA) (DeSarbo et al., 2007). The ideal number of factors to be extracted can be achieved by following different criteria: (i) perform the scree test in which all eigenvalues of the correlation matrix are plotted in descending order and choose those that occur until the last large abrupt drop in magnitude (inflection point); (ii) extract the factors whose eigenvalues are greater than 1; (iii) extract the number of factors that explain at least 60% of the total variance. The third step consists of rotating the factors to improve data interpretability. The method to be used will be varimax rotation following the recommendation of Hair (2009). The fourth step consists in calculating the factor scores and duly interpreting and attributing meaning to the factors obtained. According to Hair (2009), factor loadings between 0.3 and 0.4 are considered minimally significant and values above 0.5 are considered significant.

Multiple Regression Analysis: It is common to apply other auxiliary statistical methods to FA as the MRA to identify the relative importance of each perceptual dimension concerning the choice of a vehicle as is the case of the studies of (Jorge & Monteiro, 2011). This technique is a generalization of the simple linear regression model for cases in which there is more than one explanatory variable, studying the relationship between a dependent variable (Y) and a certain number of independent variables (xj) following the form of equation (1):

(1) $$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k + \varepsilon$$

Where k represents the number of independent variables, the coefficients β_j (j=0,...,k) represent the relative contribution of the independent variables to x_j to the overall prediction of the dependent variable Y and ε the residual standard error (Hair, 2009). In this study the independent variable will be the " likelihood of vehicle purchase" and the independent variables the dimensions obtained through FA.

Evaluation of the positioning options: Once the perceptual maps have been constructed and the positioning of the objects of study has been determined, conclusions can be drawn to facilitate strategic decision-making by decision-makers. The conclusions drawn and decisions to be taken may include: i) Verify if the current positioning corresponds to the desired one and reinforce the current position facing competitors or reposition the offer; ii) Identify a market position unoccupied by competitors and thus be able to opt for a future differentiation (C. Monteiro & Soares, 2012).

Implementation of the desired positioning strategy: Once decisions about positioning have been made, it must be communicated to the target consumers. This implies designing and implementing marketing strategies aimed at strengthening or changing consumers' perceptions (Vigar-Ellis et al., 2009).

5. Analysis and Results

Attribute selection: We identified in the literature the attributes with more influence on the consumers' decision-making when purchasing a vehicle. From the initial set of attributes, "comfort", "shape and design" and "luggage space" were removed because they do not represent a distinctive characteristic of the different types of AFV depending on the type of fuel. To complete this list with possible attributes that may not have been identified in the literature review and which could impact consumer choice, a focus group was conducted.

Focus Group: The focus group was conducted online and counted with the participation of 6 potential consumers. Some key questions were asked to generate discussion about the main attributes of the vehicles that influence their purchase decision making. From the discussion only one attribute emerged as new compared to the literature reviewed. The attribute durability/longevity of the vehicle, i.e., lifetime of the vehicle from the moment it is first purchased. In a second moment the participants were asked to share which of the attributes they considered most and least important when choosing a vehicle. Acceleration and parking costs were considered less important by the participants. On the contrary, the most important attributes were vehicle price, fuel price, engine power, comfort, repair costs, brand, safety and range. As a result of the focus group, vehicle longevity/durability was added to the initial list of attributes.

Table 1 - Final list of attributes

Nº	Code	Attribute
1	*PC*	*Purchase price*
2	*CC*	*Fuel costs*
3	*CR*	*Repair cost in case of breakdown*
4	*CM*	*Maintenance costs*
5	*AU*	*Autonomy*
6	*TR*	*Refuelling time*
7	*PO*	*Power*
8	*VM*	*Maximum speed*
9	*LO*	*Longevity/durability of the vehicle*
10	*CP*	*Parking costs*
11	*IA*	*Annual tax*
12	*NL*	*Number of parking spaces available*
13	*AR*	*Accessibility to refuelling station*
14	*AM*	*Maintenance accessibility*
15	*NEP*	*Level of pollutant emissions*
16	*PS*	*Noise pollution*
17	*PD*	*Pollution when fuel is discarded*
18	*SC*	*Driving safety*
19	*SR*	*Refuelling safety*
20	*SA*	*Safe fuel storage*

Reducing the list of attributes: To study the possibility of reducing the number of attributes and thus make the final questionnaire less dense and with this increase the probability of getting complete answers, a first questionnaire was made in which the respondents were asked to evaluate each of the attributes according to the attribute importance in the decision to purchase a vehicle. This first online questionnaire had 38 responses. Based on the results of this questionnaire the attributes "leakage pollution" and the attribute "acceleration" were excluded. On the other hand, the attributes with the highest scores were those related to safety, performance and "purchase price" coinciding to a significant extent with the attributes considered most important by the focus group. The final list of attributes was thus reduced to 20 variables which are shown in Table 1.

Data collection - questionnaire: It was time to access consumers' perceptions through an online questionnaire. A total of 183 responses were collected, 156 of which were considered valid to be submitted for analysis.

Demographic Analysis: Of the 156 respondents considered in this study 42% are women and 58% men. Most of the respondents (63%) are aged between 18 and 35. Regarding academic qualifications, most of them have a higher education degree (89%). Crossing these two criteria, age and academic qualifications, we obtain 59% of answers belonging to the target group. Since the target group is the most represented in the global sample it is expected that the results obtained considering all the answers collected may be close to the results when considering only the answers of the target group.

Factor Analysis: In the first step, regarding sample size, the requirement of having at least 100 participants is met. In addition, the ratio of observations per variable greatly exceeds the minimum acceptable of 5 observations per variable (936 observations). The correlation matrix shows that all variables meet the criterion of having at least one correlation coefficient greater than 0.3. Simultaneously, Bartlett's test with a value of 7494.556 and a significance lower than 0.001 ensures that the data are suitable to proceed with the FA. In addition, the KMO value of 0.847 points to the adequacy of the data for the analysis that is intended. The second step, the scree test, points to the extraction of five factors. Looking at the eigenvalues, only four factors present values greater than 1, although the fifth factor presents a very close value (0.978). However, the variance criterion recommends extracting the number of factors that explain at least 60% of the total variance, which happens from the fifth factor. The four-factor solution was excluded for not being able to explain at least 60% of the variance and for presenting three variables with commonalities lower than 0.5. The five-factor solution was chosen because it allowed an easy attribution of meaning to the dimensions obtained and was able to explain 62.7% of the total variance. Once the five-factor solution has been extracted, it is rotated to improve data interpretability. In this five-factor solution, all variables have commonalities greater than 0.5 so we can guarantee that their information is contained in the extracted factors. The last step consists of interpreting the factorial solution and attributing meaning to the dimensions reached. In this five-factor solution, the first factor (F_1) is called "Environment and Infrastructures". In this factor are represented with high loadings all the variables related to the environment (NEP – Level of Pollutant emissions and PD – Pollution when fuel is discarded) as well as the variables related to the infrastructures supporting the use of vehicles (AR – Accessibility to a refueling station, NL - Number of parking spaces available and AM – Maintenance accessibility. The strong representation of these two types of variables in the same factor indicates a strong correlation between them according to consumers' perceptions. Thus, high scores in this factor indicate that the use of vehicles is more harmful to the environment, however, at the same time, they benefit from better infrastructures suitable for the type of vehicle in question. The second factor (F_2) is called "Safety" since the three variables with higher loadings are the safety attributes (SR – Refueling Safety, SA - Safe Fuel Storage, and SC – Driving Safety). Thus, higher scores in this factor mean greater safety felt when using the vehicle. The third factor (F_3) is named "Economic Policies" since the variables with the highest loadings in this factor are the variable IA - Annual Tax and the CP - Parking Costs, both public policies aimed at promoting the use of AFV through economic incentives. The variable CC – Fuel Costs, despite not being defined as a public policy, appears in this factor with a loading higher than 0.4. This may be since fuel/electricity prices are subject to strong state intervention through price and tax regulation and are therefore perceived by consumers as an economic factor subject to political action. A lower score on this dimension means that vehicles benefit from better economic policies. The fourth factor (F_4) is called "Costs" because the main variables of this factor represent costs associated with the acquisition and use of vehicles. They are the variable CR - Repair cost in case of breakdown, CM - Maintenance cost, and PC - the purchase price. The variable TR – Refueling Time also appears in this factor, but with a low loading which was deemed insufficient to alter the meaning of this dimension. A high score in this factor means that the vehicle presents higher associated costs. The fifth and last factor (F_5) is named "Performance" since the variables which appear in this dimension are technical attributes of the vehicles which define their performance. The variable with the highest loading is VM - Maximum Speed followed by PO - Power, LO – Longevity/durability of the vehicle, and finally AU - Autonomy. A higher score in this factor means a better performance of the vehicle in question.

Analysis and Discussion of the Perceptual Maps: Perceptual maps were built, where each type of vehicle is represented by the average of the factor scores of all respondents in each of the five dimensions of the factorial solution obtained. Figure 2 shows the positioning map of the six vehicle types of objects of this study in the F_1 and F_2 dimensions. It is visible that the ICV are those that present a more negative impact on the environment; however, they enjoy more support infrastructures. Of the different AFV, LPG are those which are perceived as less ecological. On the other hand, vehicles with electric motors (BEV, HEV, PHEV and FCV) are perceived as having a less negative impact on the environment, with special emphasis on BEV. These are also the ones that have fewer support infrastructures. Regarding the "Safety" dimension, the type of fuel is a clear differentiator. EV are perceived as safer when compared to others.

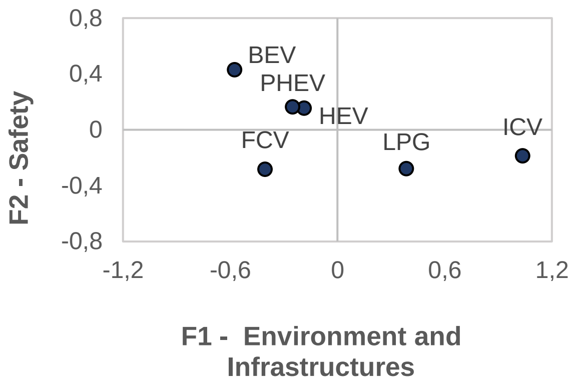

Figure 2 - Perceptual Map F1 - "Environment and Infrastructures" vs F2 - "Safety"

Figure 3 shows the vehicles in dimensions F_1 and F_3. Here we see that keeping the positions in the first dimension, it is now the factor F_3 that again makes a distinction between electric motor vehicles and the others. Again, it is BEV that enjoy better "Economic Policies", and, at the opposite pole, it is ICV that have less, according to consumers' perceptions. The only AFV that are not perceived as having favorable economic policies are LPG.

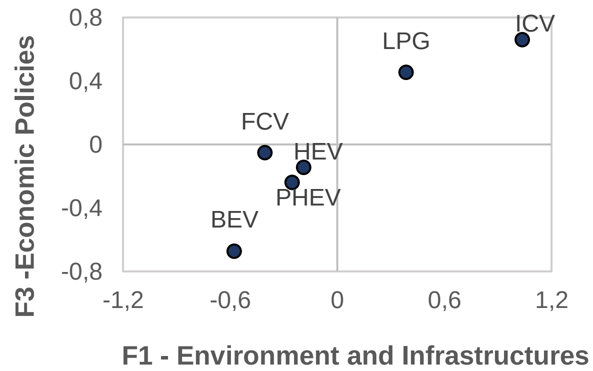

Figure 3 - Perceptual Map F1 - "Environment and Infrastructure2 vs F3 - "Economic Policies"

Figure 4 shows the perceptual map in dimensions F_4 and F_5. Again, the dimension F_4 separates electric motor vehicles from ICV and LPG. The first ones are perceived as having more associated costs, with FCV leading this list. LPG, on the other hand, are those which appear to have lower costs. In terms of performance, the ICV are the best positioned. Regarding AFV, FCV are the best positioned in terms of performance and BEV are the ones with the lowest performance, although the variance is not very high, which makes vehicles with electric motors not very distinctive in this field. In this map, the LPG appear more isolated, since their costs are much lower than the other AFV, although with a lower performance. FCV appear as the best alternative to ICV in terms of "Performance" but lose in the "Costs" dimension.

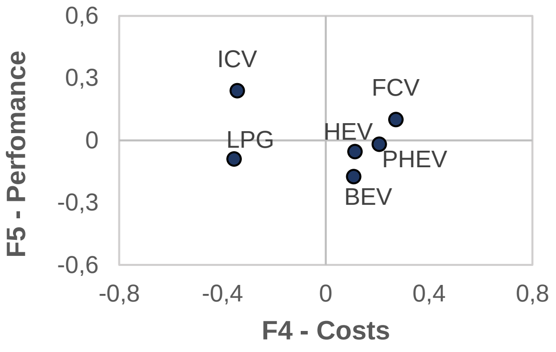

Figure 4 - Perceptual Map F4 - "Costs" vs F5 - "Performance"

Figure 5 presents the positioning according to factors F_2 and F_5. As seen earlier, battery-powered vehicles are perceived as safer than the other alternatives. ICV are the best positioned on the "Performance" dimension, although with a worse position in the "Safety" dimension. In the opposite quadrant, BEV are those whose perception regarding "Safety" is higher but with worse performance. It should be noted that in these two dimensions PHEV and HEV hardly differ, that is, consumers are not able to find competitive advantages in these two dimensions of these two types of vehicles.

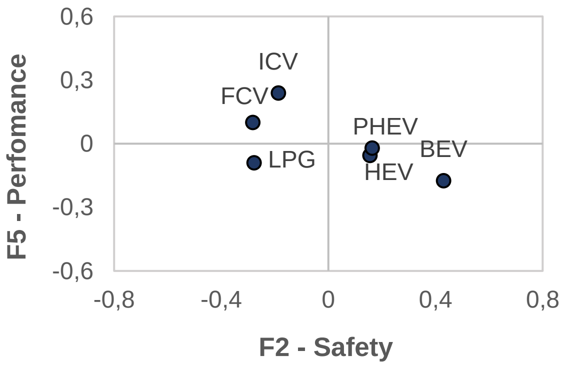

Figure 5 - Perceptual Map F2 - "Safety" vs F5 - "Performance"

Finally, Figure 6 presents the F_2 dimension against the F_4 dimension. Here it is worth noting the proximity between LPG and ICV in these two factors as well as, again, HEV and PHEV. It should also be noted that FCV appear in isolation since they are perceived as less safe and with higher associated costs.

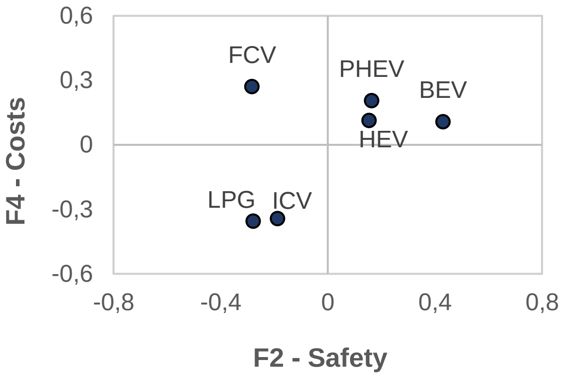

Figure 6 - Perceptual Map F2 - "Safety" vs F4 - "Costs"

These perceptual maps show us that in most dimensions the AFV are perceived as distinct from the ICV and are generally positioned in opposite quadrants. This is not the case for LPG, which are positioned close to ICV in almost all dimensions, except for the "Environment and Infrastructure" dimension and the "Performance" dimension. LPG are perceived as having a "Safety" very similar to that of ICV, enjoying few "Economic Policies" and in terms of associated "Costs" they are also little differentiated. The variable CC - Fuel Cost (explained in the factor "Economic Policies") which once could be a major difference between these two types of vehicles, due to the increase in natural gas prices, is no longer so, and this is a possible justification for the little differentiation between the two types of vehicles in this dimension. On the other hand, LPG are seen as having an inferior performance to ICV, having a larger support infrastructure network, but as being less harmful to the environment. Vehicles with electric motors (FCV, BEV, HEV, PHEV) have a transversally similar positioning with some exceptions: in the "Safety" dimension, FCV score lower than the others, motivated using hydrogen on board the vehicle to produce electric energy versus the storage of electric energy in batteries in the case of BEV, HEV and PHEV. In the "Performance" dimension, FCV are also perceived as slightly higher than the others. In the dimension "Economic Policies" these four types of vehicles are perceived as the ones that enjoy better support initiatives even though FCV with less weight compared to EV. Compared to ICV these four vehicle typologies are perceived as substantially greener, however with much higher associated costs. Thus, it is expected that these types of vehicles may be of more interest to a segment with greater economic power or with a greater concern for environmental issues. EV are perceived in a very similar way among themselves and in great contrast to ICV. The most striking dimensions are "Environment and Infrastructure" and "Economic Policies", where EV are positioned as less harmful to the environment and economically advantageous in terms of existing public policies. Concerning "Safety", EV are the best positioned, as the perceived safety of recharging the batteries and storing them onboard the vehicles is high. On the contrary, EV are perceived as having higher "Costs" than ICV and lower "Performance". On all dimensions HEV and PHEV appear very close to each other, meaning that consumers find it difficult to identify competitive advantages between these two types of EV. BEV are those perceived as better for the environment, with better economic policies and safety, but with lower performance. Thus, this vehicle type is expected to raise more interest among those who reveal to have a more prominent environmental concern.

The visual analysis of the perceptual maps also allows the identification of some empty quadrants that reveal there is no offer positioned in that perceptual space, namely, high safety and low-cost dimension that could easily be occupied by EV if they can position themselves with lower associated costs or a high safety and high-performance dimension that could be occupied by FCV if they can reinforce safety issues with the consumers or by EV if they can position themselves in the consumers' mind as having high performance.

Multiple Regression Analysis: In MRA the five factors obtained for each respondent were used as independent variables, and the "likelihood of vehicle purchase" as the dependent variable. In the solution achieved only 11% of the total variance of the dependent variable is explained by the independent variables (adjusted R^2 = 0.107). This means that knowledge of consumers' perceptions of AFV is not sufficient to predict their purchase intention. This might be due, on the one hand, to the fact that consumers' preferences towards vehicles have a great heterogeneity as seen in the literature review. In addition, according to Kotler & Keller (2016) there are other factors that directly impact on the purchase decision and that include the consumers' motivation to make the purchase, the influence that other people's opinion exerts on consumers and unforeseen situational factors that may condition the purchase intention at a given moment. Despite the model's limitations, we chose to look at the solution reached and draw possible conclusions. Since the third factor was not statistically significant in the linear regression model it was removed, and the coefficients of the multiple regression analysis allow to build equation (2):

(2) Y (likelihood of vehicle purchase) = 3,404 + $0{,}204F_1 + 0{,}451F_2 – 0{,}138F_4 + 0{,}497F_5$

This solution indicates that the intention to purchase a vehicle increases with the increase of dimension F_1 - "Environment and Infrastructures", i.e., fewer ecological vehicles, but with more infrastructures; F_2 - "Safety", i.e., vehicles perceived as safer and F_5 - "Performance", i.e., vehicles with better performance. On the contrary, the purchase intention decreases with the increase of dimension F_4 - "Costs", that is, when the economic costs associated with the vehicle increase. This solution also indicates that the most important variables for the likelihood of purchasing a given type of vehicle are the consumers' perception of the factors F_2 - "Safety" and F_5 - "Performance". These results are in line with the most important attributes as seen in the literature review as well as with the focus group results.

Differences in the positioning of the target segment: The factor analysis conducted for the target group generated a solution with a factor structure remarkably similar to the one obtained previously when considering the global sample. The sample for this segment corresponds to 93 participants (59% of the total sample where 54% are men and 46% women). The data structure met the applicability criteria for FA and the five-factor solution obtained received the same nomenclature.

The analysis of the perceptual maps constructed for the target group does not reveal great variations regarding the positioning of the vehicles in the five perceptual dimensions obtained after the application of the factor analysis. This indicates that the criteria of age and education do not seem to significantly change the consumers' perception of the vehicle attributes. The target group tends to consider AFV as having a greater positive impact on the environment. On the "Safety" dimension, consumers in this group make less of a distinction between different vehicle types. As far as "Environment and Infrastructure" and "Economic Policies" are concerned, the positioning compared to the global sample is again similar. Regarding the perceptual dimensions "Costs" and "Performance", the positioning of the vehicles is also similar with the vehicles with electric motors being positioned as having higher costs when compared to ICV and LPG and little differentiation between them. In terms of "Performance", the ICV stand out from the others with a higher score even than the score considering the overall sample, making the distance between AFV and ICV even greater in this dimension. In terms of "Costs" the positioning is also like this segment believing FCV to have lower costs and BEV to have higher costs.

The MRA was applied again to the target group to understand if there is any relationship between the factor dimensions and the likelihood of purchasing a vehicle. This time, the segmentation of the sample tries to minimize the impact of the remaining factors, among their preferences, motivations, and the influence of others' opinions, since within the target group variability tends to be smaller. In the solution reached by multiple linear regression, 14% of the total variance of the dependent variable is explained by two independent variables, F_2 and F_5 (adjusted R^2 = 0.142). This value is higher than that reached in the previous linear regression, but it continues to indicate that for the sample obtained the probability of purchasing a given vehicle is poorly explained by the factorial solution reached. Factors F_1, F_2 and F_4 did not prove to be statistically significant and were therefore not included in the final model, which corresponds to equation (3):

(3) Y (likelihood of vehicle purchase) = 3,625 + $0{,}382F_2 + 0{,}659F_5$

In this solution, the dimension with the greatest weight is again the "Performance" dimension, this time with even more expression than when considering all respondents. The "Safety" dimension continues to be the second dimension with the greatest impact on purchase intention, but with less expression compared to equation (1). This was expected since, according to the literature, safety attributes have more impact on households with older members (Li et al., 2017). It should also be noted that the factor "Environment and Infrastructures" lost weight in the purchase intention of younger consumers. This means that when considering the overall sample consumers tended to opt for less environmentally friendly vehicles, but that enjoy better support infrastructures, while younger consumers despite following this same trend, give less importance to infrastructures in favor of environmental criteria, which confirms the hypothesis discussed in the literature of the preference for less environmentally harmful vehicles increasing with decreasing age.

Positioning options for AFV strategic decisions: Consumer perceptions are quite similar in the case of the target group and the total sample. However, the purchase intention varies according to the segments analyzed, which means that the other variables involved in the purchase process, such as motivation, preferences, opinion of others, or specific cyclical factors (Kotler & Keller, 2016), should be considered for the different consumer segments. LPG are the big outlier when it comes to AFV. They have a similar positioning to ICV even though they are seen as slightly greener, but with lower performance. This suggests that LPG is unlikely to become a successful alternative to ICV unless LPG can reposition themselves in terms of performance, change their specificities, or better communicate their competitive advantages to consumers. The remaining AFV are more similarly positioned and almost impossible to distinguish in the case of HEV and PHEV. EV are seen as safer and more environmentally friendly, so they can use this competitive advantage to reach segments that privilege these dimensions. In terms of costs, these vehicles are still perceived as having more associated costs so both political and economic decision-makers should try to overcome this disadvantage as well as the lack of infrastructure to support them. BEV are perceived as the safest and most environmentally friendly, but they lose to HEV and PHEV in terms of costs and performance. Since the performance dimension is the one most valued by consumers, decision-makers should look at it and try to influence the positioning of the offers mainly in this dimension. FCV are ahead of the other EV in this dimension, which is a good omen that this type of vehicle may achieve a strong market deployment as the supply of this type of vehicles increases, namely for a younger population and with higher income/learning level, which tends to value performance more than safety and cost dimensions. Nevertheless, it will be important to try to reposition this type of vehicle in terms of its safety so that this does not become a barrier to its acquisition. Public policies aimed at promoting the use of AFV have focused their efforts mainly on economic policies such as reducing taxes on these vehicles or reducing parking costs (Liao et al., 2017), however, this dimension does not seem to have a significant degree of importance in the adoption of AFV so public institutions should rethink their support strategies and focus them on those dimensions considered more important. Therefore, one possibility could be to try to change consumers' perceptions regarding AFV performance and safety through communication campaigns. In addition, the infrastructure factor was also relevant when analyzing the overall show, so it will also be important to continue investing in good AFV support infrastructures.

6. Conclusions, Limitations and Future Recommendations

This study thus attempts to contribute to the literature and to decision-makers with information concerning the positioning of AFV based on their attributes. The factor analysis methodology was able to reduce the initial attributes to five dimensions: F_1 - "Environment and Infrastructure", F_2 - "Safety", F_3 - "Economic Policies", F_4 - "Costs" and F_5 - "Performance". An attempt was also made to understand how the perception of these attributes could impact the intention to purchase an AFV through the question "how likely is it to purchase this type of vehicle". The linear regression model did not present a very high R^2, which can be justified by the fact that other relevant conditioning factors for the purchase decision, such as personal motivations, preferences or the impact of others on the purchase decision, were not taken into account. Even so, the dimensions that the model shows as most relevant are consistent with the theses defended in the literature. The most important factors were F_5 and F_2. When the total sample was analyzed, factors F_1 and F_4 also revealed some importance, while dimension F_3 was not truly relevant. In the "Performance" dimension, the FCV with the best positioning are the FCV and in the "Safety" dimension, the EV are the ones with the best perceptions. LPG are those AFV which can least distinguish themselves from ICV, with a much worse positioning in terms of performance when comparing these two types of vehicles. The results also show that there is not much variation between the perceptions of the target group (consumers under 35 years old and with higher education qualifications) and the rest of the sample considered. As future work, we suggest the application of a Cluster Analysis to find potential additional consumer segments and potential differences in AFV perceptions. It is also suggested to use different variables to measure consumer preferences and to study other aspects with potential impact on the purchase decision. This study can also be replicated to other countries and the results compared to the Portuguese market.

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