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Analysis of the Factors Influencing the Purchase of Electric Vehicles in Brazil

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Abstract: The transport sector, and especially the increase in individual vehicle ownership, contribute significantly to air pollution. The transition to electric vehicles (EVs) is seen as a sustainable alternative to reduce emissions of polluting gases. However, in Brazil, the EV market has not yet reached a significant size. Given this scenario, this study aims to analyze the factors that influence the decision to buy EVs in Brazil, highlighting personal, psychological, economic, performance, and environmental variables and barriers. The aim is also to develop a model with guidelines that can help stakeholders. The quantitative stage of the study involved a survey of 514 respondents. The data were analyzed using statistical methods, including structural equation modeling (SEM), which allowed for a deeper investigation of the proposed hypotheses. The survey findings reveal that, in the Brazilian context, performance factors—such as autonomy, availability of recharging infrastructure, and maintenance—are the main drivers influencing EV purchase decisions. Environmental factors, including energy reuse, pollution reduction, and minimizing environmental impacts, have also gained significant importance. Economic factors are crucial, particularly concerning cost–benefit perceptions. The differences between Brazil and other regions highlight the importance of accounting for cultural and economic variations when analyzing consumer behavior towards EVs.

Keywords: vehicle electric; factors; sustainability; purchase; structural equations

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1. Introduction

Problems related to environmental degradation have gained a lot of importance in recent years due to the continuous and out-of-control emissions of pollutants resulting from various human activities, including the consumption of fossil fuels and the transportation system. Therefore, various studies are paying greater attention to the pollution generated by vehicles [1].

The global increase in individual vehicle ownership rates has been accompanied by an increase in energy consumption, contributing to the production of more polluting gases [2]. Oil-derived sources have had a considerable impact on total emissions. The exploration and use of oil or its derivatives resulted in the emission of 296 million tons of CO_2, and the transport sector played a significant role, being responsible for 204 million tons of CO_2 [3].

This is largely due to a vast transportation network, which is predominantly made up of vehicles powered by combustion engines [3].

By the end of 2022, the number of vehicles in circulation in the world reached 1.44 billion, with the transportation sector standing out as the only one that has seen an increase in polluting gas emissions over the last three decades [4]. Transport is an important factor in the urban development of cities. When aligned with urban mobility planning, it makes it possible to integrate communities into cities, providing a better quality of life and economic development [5].

In this scenario, the automotive sector is undergoing a process of change linked to the energy transition, driven by new technologies, aimed at promoting a revolution in the urban mobility scenario [6]. EVs can be considered sustainable and, in this context, their widespread use can limit emissions of polluting gases and reduce the use of oil [7].

In view of the above, many countries are looking for solutions to the issue of oil dependency, and one promising alternative is the electrification of transport, which also implies a paradigm shift [8]. The replacement of conventional vehicles with EVs is one of the main alternatives to make cities and transportation systems more sustainable [9].

Encouraging consumers to acquire EVs is an important topic for both governments and vehicle manufacturers. To address this issue, it is necessary to study consumer behavior, including the identification of the key factors that influence their choices. This means analyzing public policies and determining the best direction for investments to promote electromobility [2].

In Brazil, there were 141,291 EVs in circulation in 2023 [10]. Between January and August 2024, the market registered 109,283 EVs, representing growth of 123% compared to the same period last year [11]. The outlook for the coming years is for significant growth. However, the competitiveness of EVs compared to combustion vehicles is still limited by barriers that have persisted over the last decade, such as insufficient charging infrastructure, the high cost of vehicles, and the lack of tax incentives. As Brazil faces global challenges related to climate change, encouraging the electrification of transportation will be an important step towards reducing greenhouse gas emissions and strengthening the competitiveness of the national automotive industry.

One of the reasons that may explain the slow adoption of EVs in the Brazilian market may be related to the national prioritization of ethanol-based fuels, a strategy defined since the 1970s [12]. However, studies on this subject are extremely important, as they help to identify ways of promoting the adoption of EVs, accelerating the transition to a cleaner and more sustainable energy matrix.

Some research has already addressed this issue in the Brazilian context. For example, ref. [13] analyzed the influence of EV sharing schemes in Brazil, through planned growth policies and the retirement policy for conventional vehicles. The results showed that the combination of these policies resulted in a 29% reduction in CO_2 emissions and a 36% increase in the adoption of EVs. The study by [14] analyzed the macro-environmental factors influencing the EV and hybrid industry, highlighting that Brazil has a lucrative segment to boost the EV industry.

The study by [15] analyzed the factors that influence the intention to use EVs, using the Decomposed Theory of Planned Behavior. The results showed a positive effect on attitudes towards EVs and on the intention to use them. However, in Brazil, there are few studies on the subject of EV purchase factors. Given this panorama, the aim of this research is to analyze the factors that influence EV purchasing decisions in Brazil, proposing a model that provides guidelines to help stakeholders, using a structural equation modeling methodology.

2. Electric Vehicles (EVs) in Brazil: Policies, Incentives, and Challenges

The automotive industry has become one of the biggest generators of employment in the country, with more than 1.3 million jobs created in recent years [16]. The data related to the Brazilian industry show how much this sector has expanded, provoking reflection on the entry of EVs into the country and new trends [17].

EVs appeared on the market in the 19th century, but problems related to energy storage and battery charging meant that vehicles with combustion engines were favored [18]. EVs use one or more electric motors for propulsion, and their fuel is electricity, which can be provided in different ways, such as by connecting the external electricity source via plugs or cables, or using electromagnetic induction systems [19].

In Brazil, the Brazilian Electric Vehicle Association (ABVE) was created in 2012 with the aim of promoting the development of electromobility in the country [20]. In addition, some incentives and draft laws have also been created for electromobility in Brazil. In 2018, Aneel's Normative Resolution No. 819 of 19 June 2018, introduced subsidies to regulate the supply of electricity to EVs. In the same year, a mixed parliamentary front was formed in the country to discuss the issue at the legislative level [21].

According to ABVE (2017), as far as legislation is concerned, some Brazilian states already have incentives in place to encourage the purchase of EVs [20]. In seven states, EVs are exempt from Motor Vehicle Property Tax (IPVA), and in three states, they have a differentiated rate [20]. In 2023, in the context of the IPVA exemption for EVs in Brazil, nine states continue to offer tax benefits. The Federal District stands out by granting total exemption for hybrid and electric vehicles, and states such as Maranhão, Paraná, and Pernambuco also maintain tax incentive policies in this area [22].

Some Brazilian states offer IPVA exemption or reduction for EVs. In Rio Grande do Sul, the exemption for 100% electric cars has existed since 1996, but the specific conditions may vary; in Alagoas, there is an exemption for EVs and hybrids in the first year, with staggered rates in the following years [22].

In Minas Gerais, despite the law providing for an exemption, no national EVs currently qualify [22]. In the state of Mato Grosso do Sul, these vehicles have a 70% reduction in IPVA, while the state of Rio de Janeiro has implemented an IPVA reduction for EVs and hybrids since 2016, depending on the type of model [22].

However, the level of mobility policies designed to stimulate this sector is still low [23]. As of January 2024, the Brazilian government made it official that the import tax on EVs would return. According to the established guidelines, the rates will be gradually recomposed, reaching a level of 35% in July 2026 [24]. These changes have generated an important discussion from the point of view of users and importers, as the measure aims to foster domestic industry, boosting the development of the sector's production chain and accelerating the decarbonization of the Brazilian fleet.

2.1. Electric Vehicle Market

The Electric Vehicles Initiative (EVI) is a political forum with the aim of accelerating the adoption of EVs around the world [12]. The International Energy Agency acts as the coordinator of the EVI, and its main publication is the annual Global EV Outlook report, which presents comprehensive data on electric mobility on a global scale [25] (Figure 1).

Approximately 14 million EVs were registered globally in 2023, rising to 40 million vehicles in circulation [12]. In 2023, there was a significant increase in global sales of EVs, reaching an increase of 31% [26]. Notably, the month of December stood out with a monthly record of 1.5 million units sold, including a significant 50% increase in sales in the United States and Canada [26]. These figures indicate a positive and promising scenario for the EV industry, but sales remain concentrated in a few key markets.

In 2023, almost 60% of new EV registrations occurred in China, about 25% in Europe, and 10% in the United States, totaling approximately 95% of global sales of these vehicles [12]. China alone registered 8.1 million EVs in 2023, a 35% increase on 2022, consolidating its position as the world's largest EV market and responsible for almost half of the global fleet [12].

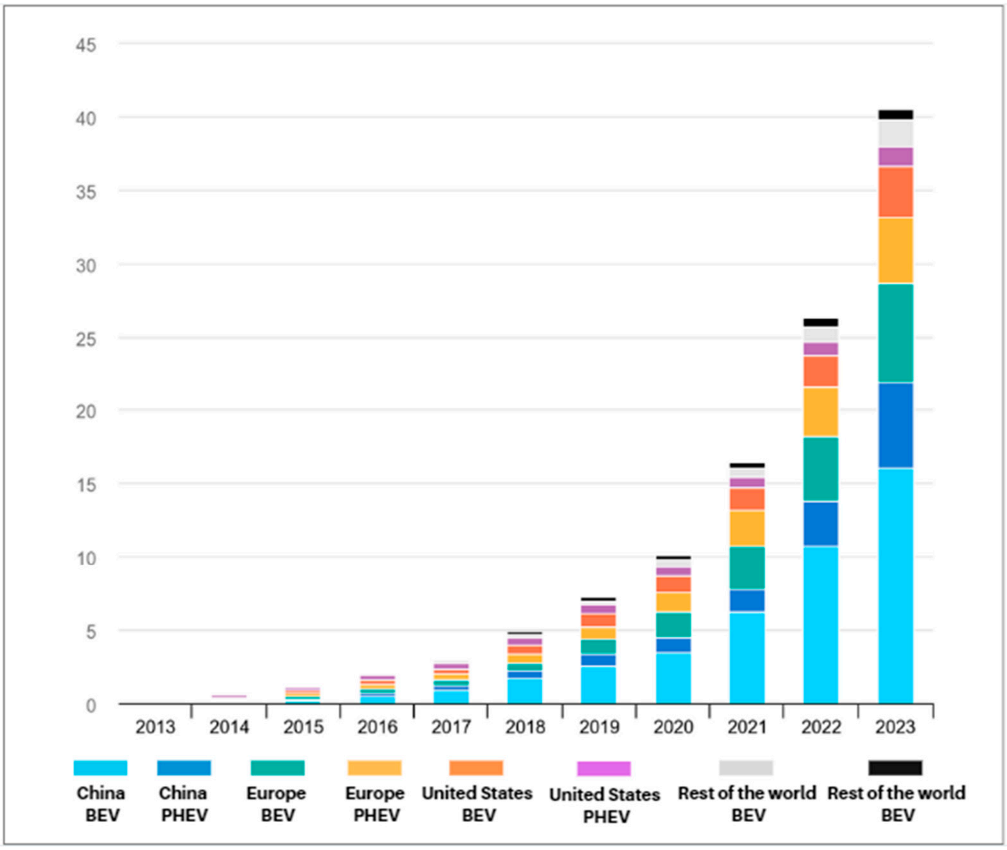

Figure 1. Global electric car stock, 2013–2023. Source: [12].

Data on the EV market show that it is growing exponentially, driven by various measures adopted to promote greater EV ownership. The average annual growth rate has increased by 65%, surpassing the rates of the last five years and, for the next eight years, an annual growth rate of 31% should be maintained [27].

This scenario demonstrates a positive trend and a significant increase in the acceptance of and demand for EVs, showing a transition towards more sustainable mobility. In emerging markets, sales are growing, albeit from a still modest base, with Southeast Asia and Brazil standing out [12].

The introduction of EVs into the Brazilian market presents various opportunities and challenges for the sectors involved. One relevant factor, which can be considered positive, is that Brazil is a climate power and has a consolidated automotive industrial park [28] (Table 1).

The promotion of EVs in Brazil has been driven by various initiatives, including the establishment of associations such as ABVE and government policies such as the Inovar Auto Project, which evolved into "Rota 2030". The Inovar Auto Project, created in 2012 by the Brazilian federal government, aimed to reduce import taxes and stimulate domestic vehicle production [29].

In 2018, it was replaced by "Rota 2030", which sought to promote innovation and competitiveness in the automotive industry, in addition to promoting energy efficiency [26]. Later, in 2023, the government launched the Mover Program, which succeeded Rota 2030. The guidelines of this new program are to increase energy efficiency, encourage the use of biofuels, and promote more efficient production systems [30].

Brazil ended 2023 with the best result in the historical series, registering 93,927 electrified light vehicles, an increase of 91% compared to 2022 [30]. EVs, hybrids, and plug-in hybrids have advanced in all regions of the country [30]. The following states stand out: Espírito Santo (+169%), Distrito Federal (+161%), Alagoas (+146%), Ceará (+113%), Sergipe

(+107%), and São Paulo (+105%) [30]. In these states, enrollment increased by more than 100% [30]. Brazil has thus achieved a 3% share of the global EV market [12].

Table 1. Market share of electrified vehicles by technology in Brazil (January to October—2024).

Technology	Market Share
100% Electric Vehicles (BEV)	37.40%
Plug-in hybrids (PHEV)	33.60%
Non-plug-in petrol or diesel electrics (HEV)	8.89%
HEV FLEX	12.61%
Micro Hybrids (MHEV)	7.49%

Source: Adapted by [30].

2.2. Consumer Behavior

Consumer behavior is the study of the processes involved when individuals select, purchase, and use products, services, or experiences to satisfy needs or desires [31]. Consumers constantly choose different brands and options for various products and services [18].

The study of consumer behavior investigates both internal consumer factors (perception, motivations, consumer learning, memory, and attitudes) and external factors (demographics, life cycle, and lifestyles), as well as the social and cultural factors that influence them [32]. These elements indicate the profile of individuals and the shared characteristics that influence consumption of the same product.

In the vehicle market, the complexity of the purchasing decision process is greater, as it is a product that is purchased less frequently and has a higher value [18]. Studying consumer behavior is extremely comprehensive, and understanding market segmentation refers to choosing a group of consumers who share the same needs or desires [33]. This segmentation can occur in various ways, with physical and behavioral variables being studied [33].

In this context, several studies use the Attitude Function Theory, which verifies the need to understand the attitudes and valuation of attributes by consumers, in order to identify the most significant attributes, and thus use the most appropriate tools [18]. Also used is the Theory of Planned Behavior (TPB), which is based on the Theory of Reasoned Action (TRA), which evaluates individual behavior through behavioral intention [34].

With its strong predictive capacity, TPB has become one of the most consolidated theories in social psychology and has been applied in several behavior prediction studies [35]. Several studies on consumer behavior in the automotive sector have used the TPB.

Among these studies is the work developed by [15], which investigated the profile of Brazilian consumers and their intention to use EVs, using an approach based on the Decomposed Theory of Planned Behavior and the influence of consumer emotions. The results showed a positive effect on attitudes towards EVs and intention to use them. In turn, author [36] carried out a study of consumer behavior with the aim of presenting the evolution of characteristics, demonstrating that there is a change in the meaning of vehicle ownership with its use.

The data indicate that motivations, personality traits, and self-concept play a significant role in shaping consumers' purchasing and consumption behaviors. However, there is a gap in the research focusing on the motivations and barriers that influence consumers' decisions when it comes to buying EVs [15]. To obtain more in-depth data on what drives this decision-making process, several countries are studying EV purchasing patterns. Using a selection of factors and variables, we developed a data collection instrument to understand the motivations and barriers consumers face when considering the purchase of EVs.

3. Methodological Procedures

This section presents the study's methods, procedures, and design, with an emphasis on the research stages. Figure 2 illustrates all the steps taken to achieve the study's overall objective. In Stage 1, a systematic literature review (SLR) was carried out on the Web of Science, Scopus, and Science Direct databases, using the words "electric vehicles" and "purchase" as the search string.

Figure 2. Stages of the methodology.

In total, 430 articles were selected, highlighting journals such as "*Sustainability*", "*Transportation Research*", "*Energy Policy*", and the "*Journal of Cleaner Production*". China stands out as the country with the most academic output on the subject, and the most recurrent keywords in the searches are "electric vehicles", "adoption", and "purchase". Based on the systematic literature review (SLR), factors and variables related to the decision to buy electric vehicles were identified and structured. Figure 3 shows the factors and variables selected for this study.

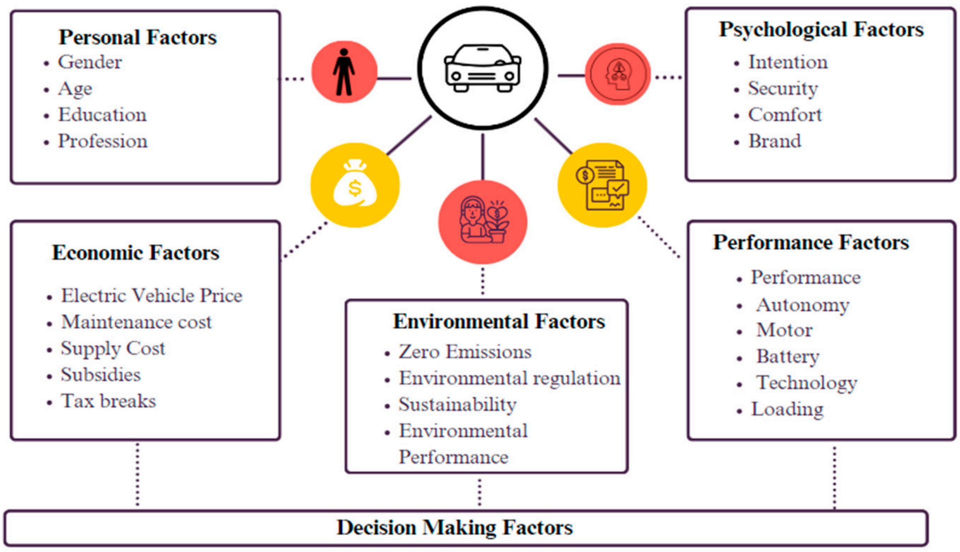

Figure 3. Factors and variables selected by the systematic literature review.

Based on the results of the qualitative stage, six main factors were defined: personal, economic, environmental, performance, psychological, and barriers. To validate five of these factors (excluding the personal factor), a questionnaire was structured with 48 related variables. This questionnaire was given to 23 experts and researchers in the field, and the Fuzzy Delphi technique was used to validate the variables. Seven variables were excluded as they did not reach the minimum consensus level of 0.6, resulting in a total of forty-one variables being retained. After this validation stage, the questionnaire was restructured, organizing the variables into thematic blocks that reflect the main factors identified in the RSL. Table 2 shows a detailed description and the scale used in the data collection instrument.

Table 2. Structure of the data collection instrument for the quantitative stage.

Block	Topic the Research	Nº of Questions
I	Personal factors	9
II	Psychological factors	4
III	Economic factors	8
IV	Performance factors	10
V	Environmental factors	9
VI	Barriers	6
Scale	Grade	Description
Escala Likert	1	Almost zero interest
	2	Little interest
	3	Medium Interest
	4	Great Interest
	5	Extremely High Interest

The scenario of this study is made up of Brazilian consumers who have already purchased or intend to purchase EVs. According to data from the ABVE, more than 140,000 electrified light vehicles were in circulation in Brazil by April 2023. To calculate the sample size, a protocol was defined as presented by [37]. Among the parameters for the calculation are the population size (N), the degree of confidence (Z), the maximum permitted margin of error (e), and the expected proportion of the sample (p). Thus, in this study, the population was defined as 141,291 EV buyers, the degree of confidence adopted was 95%, the margin of error was 5%, and the expected sample proportion was 50%. By applying Equation (1), the result obtained for the sample (n) was 384 consumers.

Equation (1)—Sample size calculation [37]

$$n = \frac{[N \times Z^2 \times p \times (1-p)]}{\{[Z^2 \times p \times (1-p)] + [e^2 \times (N-1)]\}} \quad (1)$$

The third and final stage of the study involved applying the questionnaire. After collecting the responses, statistical analysis and partial least squares structural equation modeling (PLS-SEM) were applied. This research method was chosen because of its advantages for exploratory analyses and for dealing with complex models. According to [38], PLS-SEM is useful in scenarios where models have complex structures and there is a need to deal with latent variables that are not directly observable. In addition, the method allows data to be analyzed without the assumption of normality, making it ideal for research with non-parametric or asymmetric data.

Hypotheses

Based on the three stages of the research, duly outlined above, eight hypotheses were identified and formulated as a result of the critical and investigative analysis conducted in the literature review. The theoretical and empirical contributions made by the authors consulted were fundamental in developing and structuring these hypotheses.

The hypotheses were theoretically based on the work carried out by [1,39–50]. The environmental and performance characteristics and psychological factors analyzed by [1,39–41] provided the theoretical basis for formulating Hypotheses 1, 2, 3, and 4. With regard to Hypotheses 3, 4, 5, and 6, the studies by [40–45] addressed the performance characteristics and economic factors that support them. With regard to sustainability, barriers and performance, the research by [44,45,48–50] was fundamental to the formulation of Hypotheses 6, 7, and 8. The hypotheses outlined are presented below:

Hypothesis 1. *Psychological factors are related to environmental factors. Environmental awareness and concern can strengthen positive attitudes towards EVs, resulting in a greater willingness to purchase them* [1,39–41].

Hypothesis 2. *Environmental factors are related to the performance factors of EVs, i.e., the more obvious the environmental benefits, the more likely it is that the vehicle's performance factors, in terms of energy efficiency and autonomy, will be perceived positively, influencing the purchasing decision* [1,39–41].

Hypothesis 3. *Psychological factors are related to economic factors in the purchase of EVs, i.e., a positive perception of EVs (sustainability, efficiency, and innovation) can intensify the consumer's sensitivity to economic incentives, such as subsidies or tax exemptions, thus increasing the propensity to buy* [1,39–45].

Hypothesis 4. *Economic factors are related to performance factors in the purchase of EVs. Consumers who perceive EVs as economically viable may also attribute greater value to their superior performance, reflected in greater energy efficiency and lower maintenance costs. This combined perception can positively influence the purchasing decision* [1,39–45].

Hypothesis 5. *Perceived barriers influence psychological factors. Concerns about battery life and the availability of charging points can reduce the psychological appeal of EVs, regardless of their environmental or performance advantages* [1,39–45].

Hypothesis 6. *The barriers to purchasing EVs are correlated with economic factors. This implies that challenges such as the scarcity of charging infrastructure can diminish the attractiveness of the economic benefits associated with EVs, thereby discouraging their acquisition* [1,39–45,48–50].

Hypothesis 7. *The barriers to purchasing EVs are related to performance factors. Elements such as insufficient charging infrastructure, concerns about battery life, and charging time are directly related to consumers' perceptions of EV performance. Such barriers have the potential to exert a negative influence on the purchasing decision, even when EVs perform better in other areas* [1,39–41,44,45,48–50].

Hypothesis 8. *Performance factors influence environmental factors. The energy efficiency of EVs, as a performance aspect, can reinforce environmental concerns. Consumers who are sensitive to environmental issues may be attracted by the superior efficiency of EVs compared to combustion vehicles. Thus, the perception that EVs not only meet performance needs, but also contribute to reducing environmental impact, can increase consumers' propensity to choose an EV. Figure 4 demonstrates the hypotheses formulated, with the aim of evaluating their influence on decision-making to purchase EVs* [1,39–41,44,45,48–50].

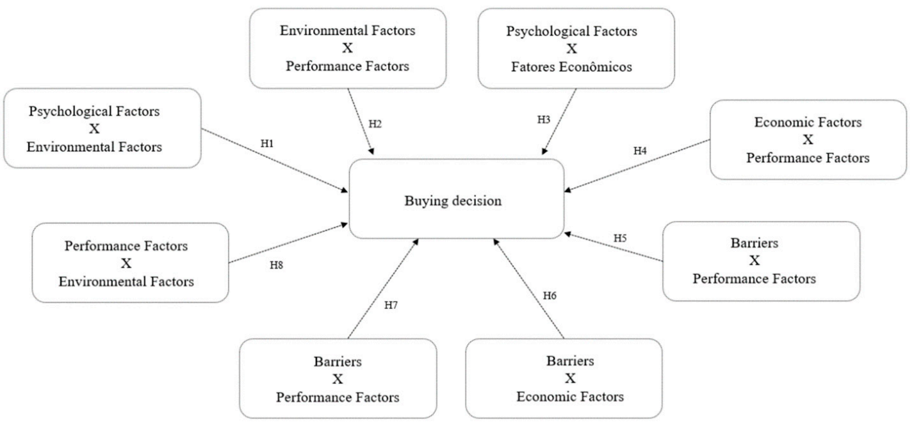

Figure 4. Conceptual model of the hypotheses.

To explore the proposed hypotheses, we developed a partial structural model based on variances. This model uses the partial least squares structural equation modeling (PLS-SEM) technique, which will be detailed in the following section.

4. Results and Analysis

This stage of the research was carried out with consumers and those potentially interested in purchasing an EV. The quantitative research method is a data collection method in which individuals report their own attitudes and behaviors through questionnaires or interviews [51].

4.1. Results of Confirmatory Factor Analysis

The factors are estimated in confirmatory factor analysis (CFA) to explain the covariances between the observed results and are considered to be the underlying causes of these variables [52]. CFA was conducted using Jamovi 2.4.11 software in order to identify the number of factors that explain the variation and covariation between the set of factors and their respective variables. The results of this analysis are shown in Table 3.

Among the items that make up the factors in the CFA, it can be seen that the vast majority, approximately 94.44%, had standardized estimate values between 0.600 and 0.900. These values indicate a strong correlation with the variables for the other aspects. On the other hand, the remaining 5.56% of the variables had standardized estimate values below 0.600, suggesting a moderate correlation with the variables of the other aspects. This variation in standardized values provides information on the intensity of the relationships between the factors and their corresponding variables in the model structure.

Table 3. Confirmatory factor analysis.

Factor	Indicator	Estimate	Erro-Padrão	Z	*p*	Estimativas Estand.
Psychological Factors	Brand	0.585	0.0533	11.0	<0.001	0.481
	Comfort	0.849	0.0376	22.6	<0.001	0.837
	Security	0.938	0.0370	25.4	<0.001	0.901
	Consumer Behavior	0.748	0.0454	16.5	<0.001	0.671
Economic Factors	Purchase Price	0.878	0.0415	21.1	<0.001	0.788
	Added Value	0.828	0.0418	19.8	<0.001	0.753
	Long-term savings	0.830	0.0370	22.4	<0.001	0.820
	Maintenance Price	0.891	0.0363	24.5	<0.001	0.867
	Recharging Price	0.943	0.0382	24.7	<0.001	0.872
	Charging System Price	0.973	0.0381	25.6	<0.001	0.890
	Tax Incentives	0.865	0.0460	18.8	<0.001	0.726
	Government subsidies	0.840	0.0479	17.5	<0.001	0.690
Performance Factors	Autonomy	0.805	0.0466	17.3	<0.001	0.677
	Recharging Time	0.924	0.0408	22.7	<0.001	0.822
	Recharging Locations	1.018	0.0385	26.4	<0.001	0.903
	Distance between Recharge Locations	1.047	0.0395	26.5	<0.001	0.906
	Recharging Infrastructure	1.018	0.0379	26.8	<0.001	0.912
	Availability of Recharging Infrastructure	1.037	0.0375	27.6	<0.001	0.927
	Battery	0.897	0.0397	22.6	<0.001	0.821
	Technological Integration	0.728	0.0441	16.5	<0.001	0.655
	Maintenance	0.795	0.0386	20.6	<0.001	0.771
	Performance	0.726	0.0424	17.1	<0.001	0.674

Table 3. *Cont.*

Factor	Indicator	Estimate	Erro-Padrão	Z	p	Estimativas Estand.
Environmental Factors	Low CO_2 emissions	1.209	0.0443	27.3	<0.001	0.918
	Environmentally Responsible	1.255	0.0425	29.5	<0.001	0.959
	Sustainable Transportation	1.248	0.0423	29.5	<0.001	0.959
	Ecological Products	1.218	0.0438	27.8	<0.001	0.928
	Environmental Preservation	1.234	0.0411	30.0	<0.001	0.967
	Reduction in Environmental Impacts	1.248	0.0412	30.3	<0.001	0.971
	Reducing Pollution	1.192	0.0409	29.1	<0.001	0.951
	Climate Change Mitigation	1.235	0.0448	27.6	<0.001	0.923
	Resources for energy reuse	1.031	0.0433	23.8	<0.001	0.845
Barriers	Lack of technical support	0.618	0.0424	14.6	<0.001	0.617
	High purchase price	0.417	0.0336	12.4	<0.001	0.542
	Limited battery life	0.788	0.0367	21.5	<0.001	0.823
	Lack of charging infrastructure	0.780	0.0373	20.9	<0.001	0.809
	Recharging time	0.855	0.0425	20.1	<0.001	0.787

4.2. Structural Equation Modeling Results

This section outlines some hypotheses that establish relationships between the variables of the proposed factors. To this end, a structural equation model was created using SmartPLS® Version 3.3.2 statistical software [53]. Based on the hypotheses previously presented, propositions were formulated for analysis and investigation. These proposed hypotheses seek to establish more specific relationships between the factors considered, improving our understanding of the underlying determinants of the EV purchase decision.

Hypothesis 6-4. *Economic factors, such as cost and financial incentives, play a mediating role in the relationship between perceived barriers (such as limited charging infrastructure and battery range concerns) and the assessment of EV performance (energy efficiency, range, and charging time). The existence of substantial financial incentives, such as government subsidies or tax exemptions, or significantly lower operating costs for EVs, can mitigate barrier-related concerns. Even when faced with practical challenges such as charging infrastructure, the economic benefits can lead consumers to perceive vehicle performance more positively. They may be more willing to accept the need to carefully plan routes to ensure recharging if this is offset by long-term savings.*

Hypothesis 5-1. *Psychological factors act as mediators in the relationship between barriers and environmental factors. Consumer attitudes and perceptions can significantly influence how they perceive and respond to barriers associated with EV adoption. A consumer who maintains conviction in the importance of individual actions for environmental protection may view barriers as surmountable challenges, rather than insurmountable obstacles. This optimism or psychological commitment can mitigate the negative impact of barriers on the purchase decision, maintaining the focus on the environmental benefits of EVs. Strong psychological factors can motivate consumers to overcome barriers to purchasing these vehicles, while maintaining a focus on environmental benefits. On the other hand, if psychological factors are weak or negative, even an environmental concern may not be enough to overcome perceived barriers.*

Hypothesis 3-4. *Economic factors act as mediators in the relationship between psychological factors and performance factors. A consumer may have a positive perception of EVs (psychological factor) and be interested in their environmental and technological performance; the final purchase decision may be strongly influenced by economic considerations, such as the initial cost, tax incentives, or operating costs of the vehicle. Therefore, even if a consumer is psychologically inclined to value* *an EV's performance, economic factors play a crucial role in transforming that inclination into a purchasing decision. If economic factors are favorable, they can strengthen the positive relationship between psychological factors and performance perception. On the other hand, if the economic aspects are unfavorable, they can attenuate or even nullify the positive impact of psychological factors on the perception of performance.*

Hypothesis 2-8. *Performance factors measure the relationship between psychological factors and environmental factors. A consumer may have a positive attitude towards sustainability (psychological factor), but their decision to buy an EV may depend on how they perceive the vehicle's performance (performance factor). If the performance meets their expectations, such as good autonomy, this can reinforce the adoption of an EV, being an effective action for the environment (environmental factor). In addition, a positive experience with EV performance can reinforce and validate consumers' psychological questions about sustainability.*

To investigate the proposed hypotheses, a partial structural model based on variances was developed using the partial least squares structural equation modeling (PLS-SEM) technique. The analysis process followed the steps proposed by [54], adapted from [55], namely, (a) evaluation of the measurement model's assumptions; (b) analysis of the structural model; and (c) evaluation of the model's hypotheses. Figure 5 shows the proposed hypotheses.

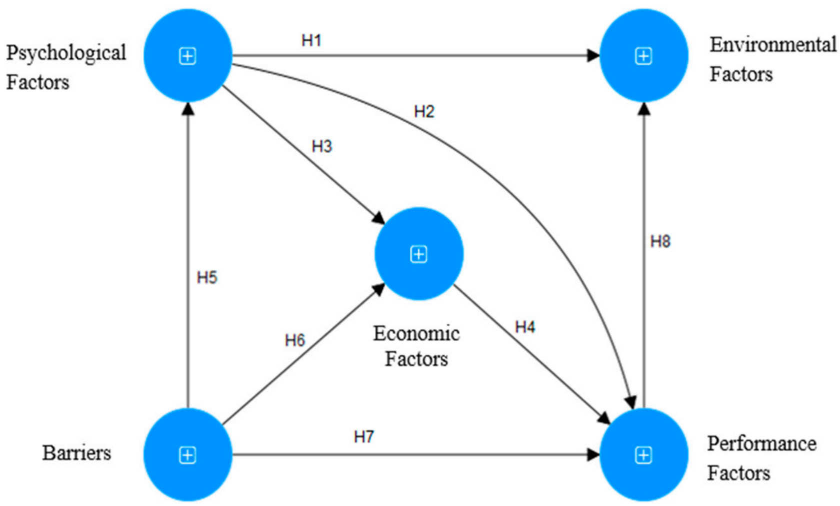

Figure 5. Proposed model and its hypotheses. Software SmartPLS® v, 4.0.9.9 [53].

The structural model achieved stability after six iterations. To evaluate the fit of the PLS-SEM model, the following criteria were used: the Standardized Mean Square Residual (SRMR) was calculated as 0.069, and the Normalized Adequacy Index (NFI) reached a value of 0.808. It is noted that the SRMR is below the threshold of 0.08 established by [56], and the NFI exceeds the cutoff point of 0.8 as indicated by [57]. These results suggest that the model fit the collected data very well.

4.2.1. Assessment of the Measurement Model

Analysis of the measurement model is essential to ensure that the factors are measured validly and reliably, which becomes particularly crucial when dealing with complex and multifaceted factors. More specifically, before proceeding with the analysis of the structural model itself, it is imperative to ensure that the factors are measured accurately and reliably, as pointed out by [58]. This robust methodological approach in the measurement phase is crucial for establishing the validity and reliability of the constructs analyzed, thus providing a solid basis for interpreting the subsequent results in the structural analysis.

4.2.2. Analysis of Internal Consistency and Convergent Validity

Table 4 shows the internal consistency metrics, represented by Cronbach's Alpha (CA) and Composite Reliability (CR), along with the convergent validity assessed by the Average Variance Extracted (AVE) in the context of the measurement model. Notably, both the CA and CC showed values between 0.8 and 0.95, and the AVE exceeded 0.5. These results indicate that the model has robust reliability and shows effective convergent validity.

Table 4. Assessment of the measurement model.

Factors	Cronbach's Alpha (AC)	Composite Reliability (CC)	Average Variance Extracted (VME)
Barriers (BAR)	0.827	0.875	0.541
Performance Factors (PEF)	0.941	0.948	0.696
Environmental Factors (ENF)	0.933	0.943	0.900
Economic Factors (ECF)	0.923	0.940	0.724
Psychological Factors (PSF)	0.815	0.877	0.646

Source: Software SmartPLS® v, 4.0.9.9 [53].

The range of values observed for AC and CC is in line with the criteria established in the literature, suggesting that the dimensions of the model are internally consistent and reliable. In addition, VME greater than 0.5 confirms that the constructs share a substantial amount of variance, reinforcing the idea that the indicators adequately capture the essence of the respective dimensions, without being compromised by measurement errors, as highlighted by [59]. These results strengthen the reliability and validity of the measurement model.

The results of the evaluation of the measurement model were analyzed for each specific category, namely, barriers (BAR), performance factors (PEF), environmental factors (ENF), economic factors (ECF), and psychological factors (PSF). Performance factors and environmental factors have high values.

Notably, performance factors and environmental factors show high values, indicating robust consistency in these dimensions. Barriers also show solid results, while psychological factors show slightly lower scores, suggesting slightly less consistency. These results highlight the reliability and validity of the measures used in each category.

4.2.3. Discriminant Validity Analysis

Discriminant validity in structural equation modeling refers to the clarity and distinctiveness of a factor in relation to the other factors in the structural model. This approach seeks to assess the extent to which the measurements of a specific factor are truly distinct and uncorrelated with the measurements of the other factors [60].

Two criteria were used to evaluate the measurement model: the Fornell–Larcker Criterion (FL) [61], proposed by Fornell and Larcher, which suggests that the square root of the Average Variance Extracted (AVE) of a dimension should be greater than the values of the correlation matrix between the dimensions of the model; and the heterotrait-monotrait ratio criterion (HTMT), proposed by [56], which is a ratio that compares the correlations between indicators measuring different factors (heterotrait) with the correlations between indicators measuring the same factor (monotrait) [62].

As shown in Table 5, the lowest Average Variance Extracted (AVE) between the dimensions (0.736) is higher than the highest correlation between FE and FD ($r = 0.734$). In addition, the HTMT values, calculated using the bootstrapping technique with 5000 subsamples, showed that the estimated upper limits of HTMT were lower than 1.0. These results indicate good discriminant validity, as recommended by [51].

Table 5. Evaluation of the measurement model.

Factors	$\sqrt{VME}$	Pearson Correlation Matrix				
		BAR	**PEF**	**ENF**	**ECF**	**PSF**
BAR	0.736	1.000				
PEF	0.834	0.445	1.000			
ENF	0.949	0.246	0.462			
ECF	0.851	0.429	0.734	0.543		
PSF	0.804	0.297	0.718	0.454	0.713	
		Upper limit $(HTMT)_{97.5\%}$				
PEF		0.612				
ENF		0.388	0.576			
ECF		0.608	0.866	0.662		
PSF		0.492	0.863	0.576	0.850	

Source: Software SmartPLS® v, 4.0.9.9 [53].

The assessment of discriminant validity is robust, as evidenced by the VME values that significantly exceed the threshold (0.5) for all pairs of factors. In addition, the Pearson correlation matrix shows moderate correlation coefficients between the factors, indicating sufficient diversity between the constructs. This reinforces the distinction between the factors and validates the measurement model's ability to differentiate the constructs adequately.

4.2.4. Evaluation of the Structural Model

As a prerequisite for evaluating the structural model, the multicollinearity between the exogenous and endogenous factors is assessed to identify possible high correlations that could compromise the accuracy of the estimates and the interpretation of the model's results [63]. The technique used to assess collinearity is the Variance Inflation Factor (VIF).

The explanation coefficient (R^2) quantifies the fraction of the variation in the endogenous factors attributed to the exogenous factors in the model [64]. The R^2 value, which varies between 0 and 1, reveals the effectiveness of the model in explaining the observed variance. On the other hand, Q^2 serves as an indicator of the model's predictive ability, often calculated using the Stone–Geisser cross-validation method, emphasizing the model's ability to predict the data [65]. Q^2 values greater than 0 indicate good predictive relevance of the model.

When analyzing the VIF values (which vary between 1.000 and 2.272), it can be seen that the model does not show excess correlation, suggesting that the prediction estimates can be reliable. As for the explanation coefficients, the performance factors explained 66% of the variance, followed by the economic factors (56%), while the psychological factors explained the least variance (9%). With regard to predictive relevance, it can be said that all the factors have a moderate degree of importance. These results suggest a good fit of the structural model to the data and its ability to explain and predict the relationships between the constructs analyzed (Table 6).

These results suggest that the structural model is capable of explaining and predicting the relationships between the variables analyzed. The *p*-value associated with the R^2 coefficients also indicates that these relationships are statistically significant. Therefore, based on the analysis carried out, it can be concluded that the model has good predictive and explanatory quality.

Table 6. Multicollinearity analysis and structural model prediction.

Exogenous Dimensions	Endogenous Dimensions (VIF)			
	PEF	**ENF**	**ECF**	**PSF**
Bar	1.226		1.097	1.000
PEF		2.066		
ECF	2.272			
PSF	2.033	2.066	1.097	
R^2 (p–valor)	0.663 (0.000)	0.244 (0.000)	0.560 (0.000)	0.088 (0.022)
Q^2	0.191	0.076	0.177	0.078

Source: Software SmartPLS® v, 4.0.9.9 [53].

4.2.5. Hypothesis Evaluation and Moderation

Next, the hypotheses proposed in the initial model are presented and evaluated, as well as the influence of the control variables (moderators) time and size on the model. Table 7 and Figure 6 show that all the direct hypotheses proposed were confirmed, and all the mediations (indirect relationships) were corroborated with statistical significance ($p < 0.05$).

Table 7. Proposed hypotheses and their mediations.

Hypotheses	Direct Relations	β	DP	Estat, t	*p*-Value
H1	PSF → ENF	0.253	0.071	3.576	0.000
H2	PSF → PEF	0.355	0.046	7.686	0.000
H3	PSF → ECF	0.642	0.044	14.556	0.000
H4	ECF → PEF	0.448	0.052	8.550	0.000
H5	Bar → PSF	0.297	0.065	4.605	0.000
H6	Bar → ECF	0.238	0.044	5.469	0.000
H7	Bar → PEF	0.147	0.039	3.749	0.000
H8	PEF → ENF	0.280	0.068	4.123	0.000
	Indirect relations (mediations)				
H6-4	Bar → ECF → PEF	0.030	0.010	3.016	0.003
H5-1	Bar → PSF → ENF	0.024	0.009	2.626	0.009
H3-4	PSF → ECF → PEF	0.081	0.024	3.316	0.001
H2-8	PSF→ PEF → ENF	0.075	0.027	2.770	0.006

Source: Software SmartPLS® v, 4.0.9.9 [53].

The results of the analysis of the hypotheses and the structural model reveal significant relationships between the factors examined in the context of the decision to buy EVs. With regard to the interaction between psychological and environmental factors, the model confirmed a positive association, indicating that consumers with psychologically favorable attitudes towards EVs also tend to value the environmental benefits of these vehicles.

The analysis of the relationship between environmental factors and performance indicates that the perception of environmental benefits increases the likelihood of consumers positively evaluating the performance of EVs in terms of energy efficiency and autonomy. The results obtained by [42] confirm that environmental concerns positively affect the public's intentions to use EVs in the future. In a study carried out in Hong Kong, the relationship between the influence of environmental concerns and perceived value resulted in significant effects on purchase intention [66]. The results on the influence of performance are in line with the studies carried out by [67,68], which showed a significant relationship between performance and the adoption of EVs.

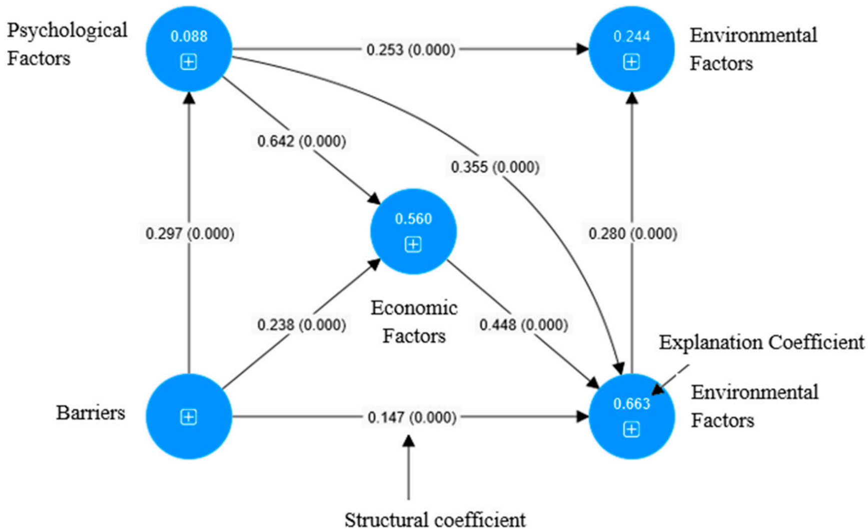

Figure 6. Final structural model. Software SmartPLS® v, 4.0.9.9 [53].

With regard to psychological and economic factors, the research results confirm the proposed hypothesis. They show that a positive perception of EVs, with an emphasis on efficiency and innovation, makes consumers more receptive to economic incentives, such as subsidies or tax benefits. This confirmation highlights that the way people view EVs can influence their purchasing decisions, increasing their sensitivity to the financial advantages offered. Thus, an optimistic and encouraging view of EVs not only attracts more interest, but also makes consumers feel more motivated to consider these incentives when deciding to buy. This confirmation is in line with the results found by [46]. The author points out that the influence of financial incentives is one of the main motivators of purchase intention, since any type of incentive that affects the price to be paid is perceived positively by the participants.

An analysis of the relationship between economic factors and performance shows that aspects such as cost and financial incentives have a significant impact on the perception of EV performance. This finding is in line with the results obtained by the authors [69], who point out that the willingness of Spanish drivers was impacted by factors such as cost, information about the technology, and autonomy of EVs. In the same context, [70] considers that financial benefits, performance and infrastructure have a significant impact on consumers' purchasing intentions. In addition, [71] highlighted the autonomy and cost of EVs in purchasing decisions.

5. Analysis of Results and Discussions

The analysis of the hypotheses proposed in the initial model, together with the evaluation of the influence of the control variables (moderators) time and size, revealed consistent and significant results. The confirmation of all the direct hypotheses proposed suggests that the relationships between the constructs investigated are robust and in line with theoretical expectations. In addition, the confirmation of all the mediations (indirect relationships) indicates the presence of significant paths and more complex interconnections between the variables in the model. These results provide a solid basis for understanding the dynamics underlying the phenomenon studied. The positive or negative influence of moderating variables, such as time and size, stands out as an additional aspect that contributes to the complexity of the model.

The results obtained strengthen the validity and robustness of the proposed model, providing a comprehensive understanding of the relationships between the constructs and their practical implications. This analysis makes a significant contribution to knowledge in the field, offering relevant information that can guide strategies and decision-making in similar contexts. Figure 7 shows the key variables highlighted, which can be used as auxiliary tools in decision-making, providing a guide to facilitate the decision-making process.

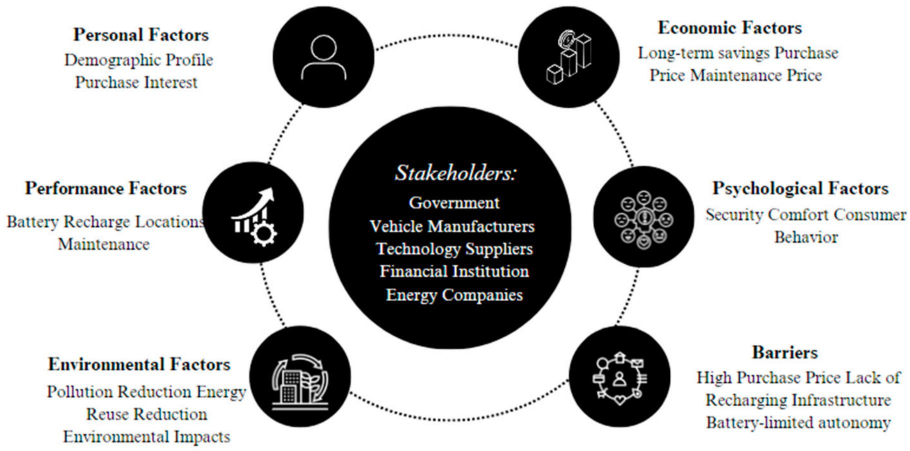

Figure 7. Key factors and variables.

This interconnection provides information to understand the mechanisms underlying the decision to buy EVs and to guide strategies in marketing, public policy, and product development in this context. Based on the results of the structural model and the understanding of the interactions between the influencing factors in the EV purchase decision, various strategies can be implemented in different sectors. Figure 8 highlights some examples of guidelines relating to personal factors.

	Success Variables	Guidelines to assist Stakeholders
Personal Factors	• Age • Sex • Education • Income • Purchase Interest	• Segment the EV market; • Development of Products and Services aligned with local needs; • Development of Education and Awareness Programs.

Figure 8. Guidelines for personal factors.

Considering the personal factors and the data obtained on the success variables, the implementation of market segmentation would be an important aspect. This strategy will allow for a better understanding of the different needs and perspectives of different types of consumers. According to [72], it is crucial, especially in the Brazilian context, to understand the market and the motivations that lead consumers to buy EVs.

With market segmentation, it is possible to create financial incentives that take into account the relationship between a customer's income and their intention to buy a vehicle. As pointed out by [39], the importance of the economics related to the prices and costs associated with these vehicles stands out.

By collecting information on personal variables, it becomes feasible to develop products targeted at market needs, while gaining a deeper understanding of local demands and the strategies and services that can be adopted. In this context, understanding the market allows us to adapt more effectively to changes in consumer preferences and needs, as well as promoting the creation of products and services that are in line with the expectations of those potentially interested in acquiring EVs. Figure 9 highlights some examples of guidelines relating to performance factors.

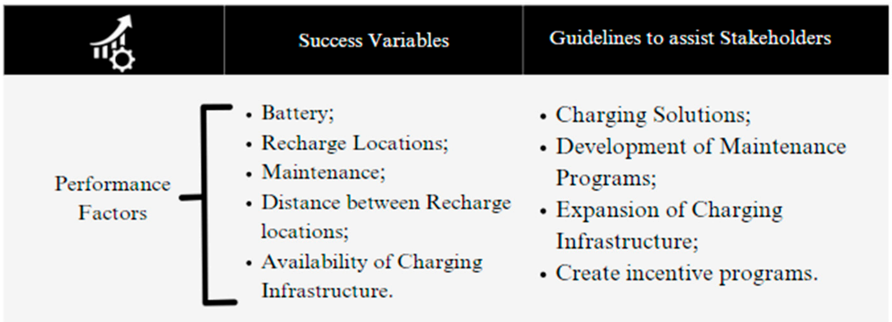

Figure 9. Guidelines for performance factors.

In the performance factors, three of the five success variables related to recharging stand out, indicating a significant concern on the part of the participants about this issue. As a guideline, we suggest a more detailed assessment of the distance between charging points and the places frequented by EV users, with a view to expanding this infrastructure more efficiently. As pointed out by [73], the availability of information on charging infrastructure contributes to greater adoption of EVs. Another guideline that could be considered is the promotion of incentive programs for the installation of residential infrastructure.

The implementation of rapid recharging technologies can also be highlighted, as the variables relating to charging were one of the evident concerns in this study. As emphasized by [74], it is crucial to pay more attention to the deployment of a sufficient number of chargers, as this deployment plays a crucial role in accessibility and demand. The researchers point out that the adequate presence of chargers is one of the critical factors that make a big difference in the EV market, as evidenced by the study involving 20 countries.

As far as maintenance is concerned, it is possible to adopt guidelines for preventive maintenance programs, which guarantees better vehicle efficiency and can minimize cost-related concerns. The author of [1] emphasizes that in order to promote the EV market, it is essential to pay greater attention to the quality and extent of services, including guarantees for the main components of EVs. Figure 10 highlights some examples of guidelines relating to environmental factors.

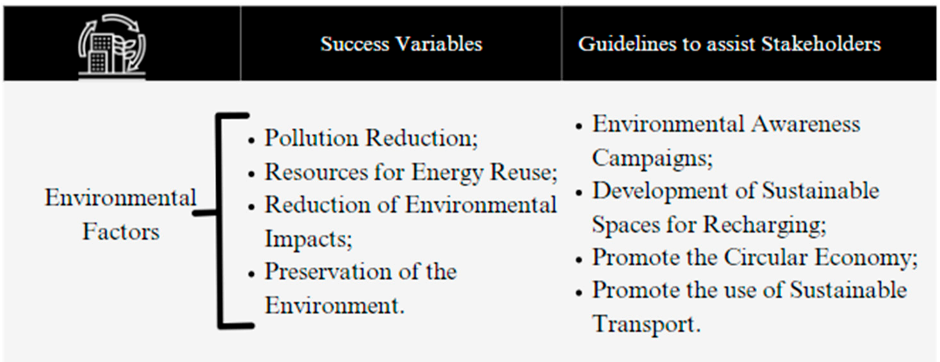

Figure 10. Guidelines for environmental factors.

With regard to environmental factors, it is possible to develop environmental education guidelines. As noted by [75], environmental impact is among the most significant factors that consumers take into account when considering the purchase of an EV. The authors emphasize the need for perceived environmental benefits and positive actions related to the purchase of EVs.

With regard to energy reuse resources, it is possible to promote development and encourage the adoption of innovative resources. By integrating the concepts of reuse and recycling, it would be possible to boost the circular economy [76]. These initiatives optimize the use of resources and also contribute to environmental sustainability.

Another highlight is the development and expansion of infrastructure networks, encouraging a broader approach to sustainable transportation. With regard to emissions, partnerships can be made to promote carbon footprint monitoring systems, encouraging practices to reduce emissions of polluting gases. Figure 11 highlights some examples of guidelines relating to barriers.

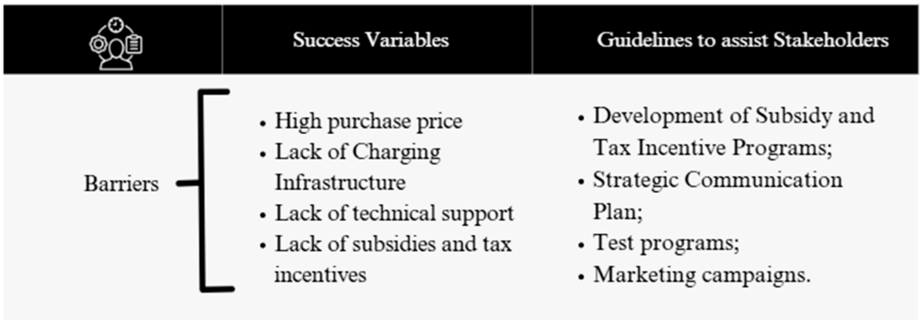

Figure 11. Guidelines for barriers.

As for barriers, encouraging the adoption of EVs involves developing subsidy and tax incentive programs. For example, the United States has adopted tax credit measures to boost the EV market.

In addition, targeting vehicle testing programs can be an essential measure, as it can allow potential buyers and interested parties to get to know EVs, reducing the negative perceptions associated with barriers. As highlighted by [77], it is crucial to incorporate driving tests during the EV sales process, demystifying preconceived ideas that these vehicles are unsuitable and have insufficient autonomy. This approach helps to transform attitudes and promote wider acceptance of EVs.

An important way to attract new users is to create marketing campaigns that show the benefits that adopting EVs can bring. For the adoption of EVs in Brazil to advance significantly, it is essential that policymakers consider the barriers identified and develop a structure that favors both supply and demand. One approach would be to build consumer confidence in the autonomy of EVs. In addition, policies that encourage the research and development of more efficient battery technologies can help reduce costs and increase competitiveness.

6. Conclusions

The main objective of this study was to analyze the factors that influence the EV purchase decision in Brazil and to develop a model with guidelines to help interested parties. Initially, through a systematic literature review in the WOS, Scopus, and Science Direct databases, the factors and variables that can influence consumers' decision to buy EVs were investigated. The next phase of the study was carried out using a structured survey with 52 questions divided into six different sections (see Supplementary Materials). These questions were submitted via an electronic form and a total of 514 responses were obtained.

The use of structural equation modeling (SEM) was an important approach to investigating the proposed hypotheses. The results highlight the interconnection between psychological and environmental factors, showing that positive attitudes and perceptions towards EVs are associated with environmental awareness and concern. Positive perceptions of EVs, combined with economic incentives, can mitigate barriers and strengthen the relationship between psychological factors and performance.

Based on these findings, it is recommended that policymakers and companies adopt concrete measures to encourage the adoption of EVs in Brazil by attracting investments to improve the charging infrastructure, expanding the network of charging points in urban areas and on highways, with the aim of increasing consumer confidence when buying a vehicle and having charging available. In addition, the implementation of incentives and subsidies for the installation of charging stations could make these vehicles more accessible to a greater number of consumers. These initiatives would not only boost the adoption of EVs but would also contribute to promoting a more sustainable energy matrix in the country.

The main limitation of this study lies in obtaining the responses, which were mainly concentrated among EV users, and in the participation of interviewees from other Brazilian states. Future studies may expand the sample to other Brazilian states, which would allow for a more comprehensive analysis of the variables.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16229957/s1, Questionnare.

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