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The Electric Vehicle Market in Brazil: A Systematic Literature Review of Factors Influencing Purchase Decisions

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Abstract: Technological advancement has propelled global economic growth, but it has also led to high rates of pollution emissions, underscoring the urgency of environmental issues. The transportation sector, particularly the rise in individual vehicle ownership, significantly contributes to atmospheric pollution. In this context, Brazil faces growing challenges, largely due to the high number of individual motor vehicles. Transitioning to electric vehicles (EVs) is seen as a sustainable alternative to reduce emissions of polluting gases. However, it is important to consider that EVs may indirectly generate pollution due to energy production in thermal power plants. Nevertheless, EVs are often sought by countries to reduce dependence on imported fuels and to mitigate urban pollution. This study aims to understand the factors influencing the purchase decision of EVs in Brazil through a systematic literature review and validation by specialists using the fuzzy Delphi method. The results indicate 37 variables, grouped into five main blocks: psychological factors, performance factors, environmental factors, barriers, and prospects for the automotive sector. The validation of these variables by specialists provides a solid foundation for the next stage of the research, which involves administering the questionnaire to the general community. Considering these results will lead to strategies aimed at promoting EV adoption, in line with global sustainability challenges and the reduction in CO_2 emissions.

Keywords: sustainable incentive; electric vehicles; carbon emissions; fuzzy Delphi

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1. Introduction

Technological development has significantly boosted the global economy, leading to consequences such as high rates of pollutant emissions and unrestrained consumption resulting from the extraction of natural resources and the use of fossil fuels [1]. All this economic growth is based on flows of extraction, production, use, and waste, as well as large greenhouse gas (GHG) emissions into the environment, threatening the availability of resources [2].

In the current context, there are a large number of vehicles in circulation together with a significant growth rate over the years, making transportation one of the major contributors to the emission of pollutants into the atmosphere [3]. Climate change has become a challenging issue due to its large scale, irreversibility, and high uncertainty [4].

Thus, in the year 2015, the Paris Climate Agreement was created to promote initiatives and measures to reduce GHGs from 2020 onwards, limiting global warming to an increase of 1.5 °C by the end of the 21st century [1]. Transport is responsible for 25% of the world's carbon dioxide (CO_2) emissions, and light vehicles are responsible for most of these emissions [5].

Faced with this panorama, several countries are concerned about reducing pollution levels, including the European Union, which has set a goal to reduce CO_2 emissions from cars by 2030, with car manufacturers having to reduce CO_2 emissions into the atmosphere by 37.5% [6]. In addition, manufacturers will also need to invest in technological innovations to promote decarbonisation, because it is necessary to achieve a 90% reduction in emissions from the transport sector by the year 2050 to achieve climate neutrality [7].

The promotion of electric vehicles (EVs) makes it possible to contribute to carbon reduction targets, which effectively restricts urban air and noise pollution [8]. For manufacturers to effectively reduce pollutant emissions, everyone must invest heavily in increasing the adoption of electric and hybrid vehicles as a strategy to meet the targets set in the Paris Agreement [6].

To find efficient approaches to reducing air pollution and oil consumption in the transport sector, there are two possibilities [9]. One is by improving the energy efficiency of internal combustion engines, while the other is using alternative energies [9]. However, EVs, powered by electricity, are highly energy efficient and can be considered an alternative in the transportation sector to address energy and environmental problems [10].

The transport sector in Brazil has a high number of individual motor vehicles, which shows that there are several reasons for buying cars, including the inefficiency of public transport policies [11]. In 2018, the Brazilian population made 67 billion trips (corresponding to approximately 223 million trips per day), of which individual motorised transport accounted for 20.3 billion trips, followed by public transport, which generated 18.8 billion trips [12].

Individual motor vehicles are one of the main means of transportation in Brazil. Therefore, greater adoption of EVs is necessary, as these vehicles can help to decarbonise by reducing CO_2 emissions [13]. It is therefore essential to conduct studies to identify the factors that influence consumers' decision to buy EVs and to formulate policies [14]. To this end, various studies on consumer behaviour in the automobile sector have been carried out, including [9,15–39], among others.

In this context, we can see that EVs have several competitive advantages. However, there is still a lack of public and private resources for greater adoption of these vehicles, showing that there are opportunities to be explored in this sector [40]. To this end, the aim of this study was to identify, through a systematic literature review (SLR) in the Web of Science, Scopus, and Science Direct databases, the factors and variables that can influence the decision to buy this type of vehicle, and to validate the variables based on the perception of experts, using the fuzzy Delphi method.

2. Electric Vehicles: Main Concepts

The need to adopt policies related to sustainability and the reduction in greenhouse gas (GHG) emissions has led to the search for new alternatives, a trend that has intensified since the 2000s [41]. This led to new research into the development of electrically powered vehicles and new discussions about the consequences for the environment at the end of the 20th century; these innovative technologies have become increasingly important given the technological development of the sector [42].

An EV consists of a battery that provides energy, a motor that drives the wheels, and a controller that regulates the flow of energy; it can be considered promising for the use of renewable energies with extremely low carbon emissions [43]. Another advantage that can be highlighted refers to the use of its battery as an energy resource, making these vehicles intelligent solutions for better use of energy, obtaining better efficiency from their engines [44]. (See Figure 1).

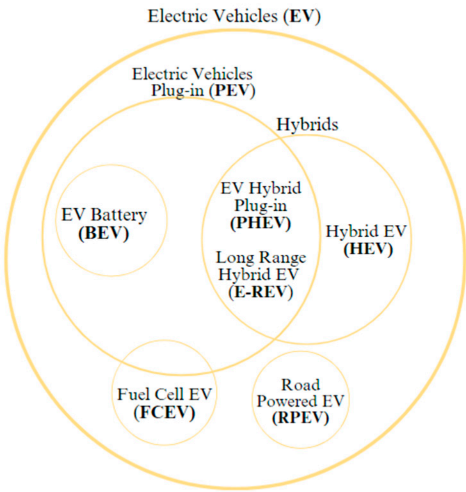

Figure 1. Types of electric vehicles. Source: adapted from [44].

There are different types of EVs, and although they all use electricity, the way they use it is different. Hybrid vehicles operate with an internal combustion engine in conjunction with an electric motor, which increases the vehicle's range and reduces emissions, while battery electric vehicles have an exclusively electric motor, consuming electrical energy stored in a battery [45].

With regard to charging stations, which can be known as electroposts, charging points, or electric vehicle supply equipment (EVSE) or electric vehicle charging station (EVCS), these stations are responsible for supplying electricity to recharge the batteries [44]. These points include connectors, wires, accessories, and other associated equipment that are connected to the inputs of EVs and provide electricity to charge the vehicle batteries [46].

The use of electric motors has advantages such as lower emissions of pollutants into the environment, greater energy efficiency, better performance, and lower maintenance costs when compared to combustion engine vehicles [47]. The search for more efficient cars with lower maintenance costs and better range has made EVs a preferred option [48].

2.1. Electric Vehicles in Brazil

In Brazil, the electromobility scenario began in 2010 with the implementation of pilot projects with different modes of operation, from traditional automakers already established in the country to new entrants, electricity distributors, and associations that encourage and assist these activities [49].

In 2012, the Brazilian Electric Vehicle Association (ABVE) was created as a civil association under private law, seeking to make decisions that encourage the adoption and development of EVs with the objectives of developing, demonstrating, and marketing these vehicles in Brazil [50].

Some incentives and bills have been created for electromobility in Brazil, such as in 2017 through Bill No. 454/2017, which decreed that from 1 January 2060, there will be a ban on the sale of new combustion engine cars; however, the bill was shelved in December 2022 [51]. (See Table 1).

Thus, in addition to policies to encourage the use of electric vehicles, there is also an incentive to produce these vehicles, but the level of mobility policies aimed at stimulating this sector is still low [52].

In general, Ref. [49] describes how in Brazil, the government measures to promote electromobility are mixed with those to promote green technologies, with two axes of action—one that is more general and relates to the theme, and the other consisting of actions specific to VES. Specifically, the indirect actions include the Air Pollution Control Program for Motor Vehicles (PROCONVE—1986); National Policy on Climate Change (PNMC—2008); Vehicle Labeling Program (2008); and Inovar-Auto (2013–2017). Direct actions include the

BNDES Climate Fund Program (2011); FUNTEC (2006–2018); BNDES Investment Sustainability Program (2011–2015); Efficient Capital Goods—BNDES (2016); Car Sharing Project (2015); ANEEL Regulation (2018); and Law No. 13. 755 of 10 December 2018—Rota 2030—Mobility and Logistics (2018–2033).

Table 1. Examples of electromobility bills in Brazil.

Propositions	Menu
710/2023	Installation of charging points for electric and hybrid vehicles in public parking lots and public roads.
1621/2022	Determines that new electric vehicles sold in Brazil must contain a charging cable that connects to charging stations according to a nationally standardised configuration, in the form of a regulation.
2397/2021	Mandatory toll exemption for electric vehicles in future highway concession notices published by the National Land Transport Agency (ANTT).
3174/2020	Incentives for electric vehicles, based on a tax cut and a change in the federal government's fleet.
5308/2020	Exempts imports and exports of electric or hybrid vehicles from the tax on industrialized products (IPI).
3435/2019	Mandatory installation of charging points for electric and hybrid cars in covered parking lots with more than 200 spaces.
3197/2019	Mandatory installation of charging points for electric vehicles on public roads and in residential and commercial environments.
1964/2019	Incentives to expand the use of electricity to power motor vehicles.
1618/2019	Mandatory charging points for electric vehicles in new residential buildings.
874/2019	Measures to promote an increase in the number of public charging points for electric vehicles.
874/2019	Measures to promote an increase in the number of public charging points for electric vehicles.
9616/2018	Tax incentives for the production and sale of vehicles powered exclusively or partially by electric motors.

Adapted from [53].

In view of all these regulatory aspects, together with energy efficiency factors and climate issues, Brazil is increasingly looking for cleaner and more efficient vehicles. However, several technical challenges and barriers are emerging to the greater inclusion of these vehicles in the Brazilian fleet [44].

In this context, the Brazilian EV scenario still has points that need to be improved, such as high purchase prices, limited autonomy, and a lack of charging infrastructure [54]. However, the search for improvements in environmental sustainability and technological advances have made EVs a viable alternative, making them more competitive and more widespread among consumers [55].

2.2. Electric Vehicle Market in Brazil

Brazil has a long tradition in the automotive sector. However, it has a low performance in the sale of electric vehicles when compared to other countries, with approximately 1.8% of the vehicles sold in 2021 being electric [56]. This reveals a certain inertia in the Brazilian automotive sector in the face of a possible technological transition to electromobility [57].

Factors such as the corporatist relationship of the main players in the automotive industry, high international technological dependence, the establishment of an alternative technological route, and the lack of policies for this technological transition end up directly affecting performance in this area [58].

An important step was the emergence of Brazilian associations to encourage EVs, such as the Brazilian Electric Vehicle Association (ABVE), which aims to promote the EV market through incentives [59]. Despite all the efforts, incentives, and industries, the trade in EVs in Brazil is still low; however, this scenario is constantly changing.

In 2012, the federal government launched the Inovar-Auto project, to reduce import duties from 35% to 0, 2%, and 5% for vehicles whose components are imported and assembled in the country, and 2%, 4%, and 7% for complete imported vehicles, to encourage the purchase of EVs [60]. This project came to be known in 2018 as "Rota 2030", Law No. 13.755, and is a remodelling, with the focus on encouraging R&D projects throughout the sector chain [61].

The "Rota 2030" programme follows a number of guidelines, including the establishment of mandatory requirements for the sale of vehicles in Brazil, stimulating the production of recent technologies and innovations, increasing investment in R&D, and guaranteeing the expansion of employment in the mobility and logistics sector [62].

By 2022, the stipulated targets followed the guidelines of the Inovar-Auto programme (12.08% reduction in consumption compared to 2011 levels); as of 2023, the targets will follow the proposals of the "Rota 2030" programme, including an 11% reduction in fuel consumption for cars and light commercial vehicles [62].

The Brazilian EV market registered 9537 units in October 2023, an increase of 114% compared to September 2022, confirming the first half of 2023 as the best in the historical series, with a total of 67,047 EVs sold [63]. These figures demonstrate the growth of the market, which totalled 193,486 electrified light vehicles in circulation in Brazil [63].

In 2023, hybrid vehicles (HEV) registered 540 registrations in the month, while plug-in hybrid vehicles (PHEV) reached 1733 registrations, totalling 135,301 EVs in circulation in Brazil [63]. These data are extremely important for the Brazilian EV market, as they show that consumers are gaining more confidence in buying electrified vehicles and that measures are being adopted, such as the installation of more electric stations and new incentives.

The automakers that sold the most EVs in March 2023 were Toyota, Caoa Chery, Volvo, BYD, Land Rover, Porsche, and Honda. In the second quarter, there were changes in the Brazilian market, with the best-selling vehicles coming from BYD and GWM. Figure 2 shows the 10 best-selling models in 2023.

It is encouraging to see the progress made in charging infrastructure for EVs in Brazil. The implementation of charging station infrastructure is fundamental to increasing the adoption of EVs, as it provides consumers with greater autonomy, allowing users of these vehicles to make longer journeys with the peace of mind of finding recharging points [65]. In 2022, partnership projects were structured between Zletric, Nissan, Movida, and Rede SIM [65].

However, despite the existence of a wide variety of vehicle models on the Brazilian market, the costs are still borne only by classes A and B. Compared to the rest of the world, Brazil still offers few incentives and subsidies to encourage the adoption of EVs [44]. Research conducted in 2018 by the Energy Research Company (EPE) on the future of electric mobility in Brazil served as a basis for government decision-making [66]. The results of this research show that by 2026 the fleet of EVs in circulation will be 360,000 vehicles [67].

Given this context, we can see that the EV market in Brazil is very promising, showing that all these technological challenges could generate countless jobs, capital, and innovations. In addition, the energy saved would help prevent the waste of resources [68].

Electromobility in Brazil needs studies that reinforce discussions on this subject, contributing to the increased use of EVs, offering policies to boost the economy of this sector, and the development of strategies to attract new investments for the expansion of the network [69].

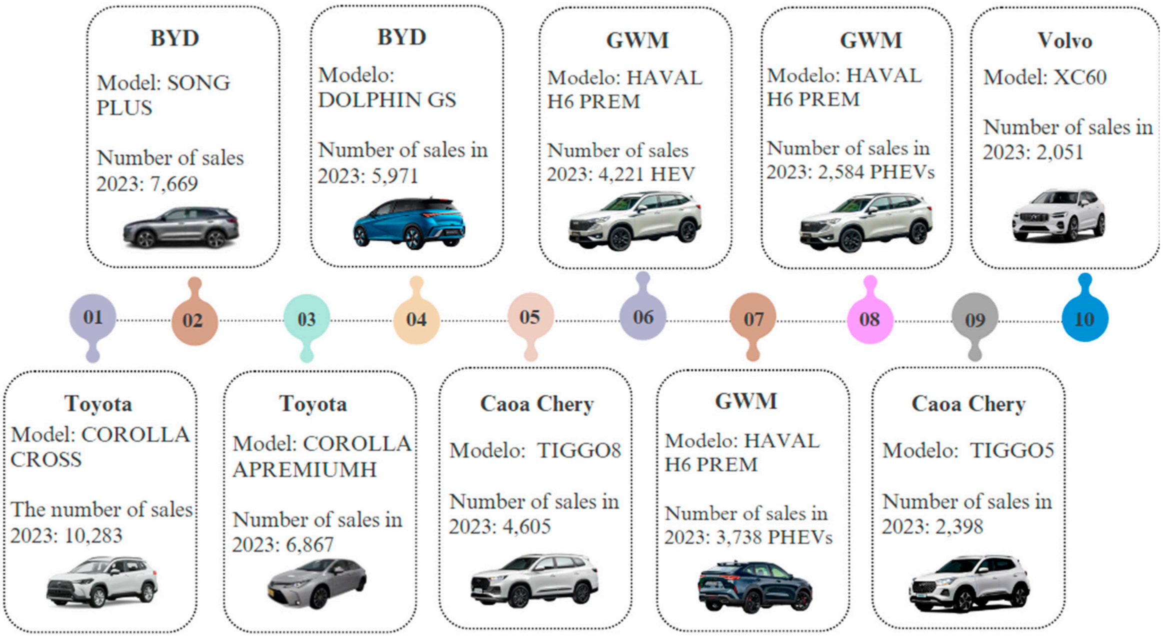

Figure 2. The 10 best-selling EV models in 2023. Source: [64].

2.3. Factors in the Decision to Buy Electric Vehicles

The Brazilian automotive sector is characterised by a certain inertia in the face of a possible technological transition to electromobility [52]. Over the years, numerous studies have been conducted to evaluate the process of consumers buying electric vehicles [70]. In this segment, one factor that always stands out is the purchase price, which ends up influencing consumers in the purchasing process [71]. In recent years, consumer opinion has changed, and other factors are also coming into play. The reasons for these changes may be related to cost improvements and new purchase subsidy incentives [72]. Another factor that has come to the fore in recent years as an influence on the purchase of EVs is environmental performance, as consumers are seeking greater knowledge about sustainability and ecology [73].

Other factors such as the make of the vehicle, maintenance costs, safety, comfort costs, and insurance are also characterised as factors in the decision to buy EVs [71]. Some factors can still be considered as a constraint for the purchase of EVs, including charging duration, driving range, and station density, demonstrating the importance of investments in infrastructure to ensure the future of the market [74].

Of the articles evaluating innovation in the automotive industry, Ref. [6] examined the impact on the intention to work with EVs. Instrumental attributes involve discharge time, autonomy, number of charging stations, and cost of acquisition; symbolic characteristics refer to lifestyle, image of EV use, and zero impact emission. Environmental attributes concern what it suggests to be environmentally responsible, which means it has an impact on what is environmentally friendly, while identity attributes are linked to understanding with its ideologies and relying on details and opinion [6].

In the work conducted by [27], the aim was to assess the barriers and motivations that can influence the intention to buy EVs by considering the following factors: lack of knowledge, high price, anxiety about autonomy, infrastructure, charging time, environmental concerns, and financial incentives.

Several nations have carried out research to comprehend consumer buying habits regarding vehicles in order to grasp the factors that impact EV purchase decisions. Notably, China has been actively engaged in conducting studies on this topic.

As an example, the authors of [32] analysed the theory of planned behaviour to predict the purchase intention of battery EVs, evaluating factors such as environmental performance, attitude, behavioural control, and incentive policies. In addition, the authors [34] evaluated the purchase intention of consumers in the city of Beijing, considering variables such as attitude, subjective norms, and behavioural control.

In Italy, the work conducted by [75] showed four components in the first analysis: pleasantness, traditional driving habits, environmental concern, and perception of purchasing control. A multiple regression showed that the intention to buy in this country may be associated firstly with pleasantness and then with environmental concern [75]. The authors of [76] conducted a systematic literature review (SLR) on the subject, based on three main categories: consumer characteristics, EV characteristics, and related policies.

Numerous factors and criteria are used to make the decision to buy EVs, and each country approaches these analyses differently. The factors that influence consumer decision-making in the purchase of EVs vary, based on a combination of psychological, environmental, economic, personal, environmental, and performance factors [36].

3. Method

This study was conducted in two stages, as shown in Figure 3. The systematic literature review (SLR) makes it possible to identify existing knowledge in the area selected for the study, utilising a research question. This approach makes it possible to analyse factors such as the evolution of studies, the most cited authors, and the countries of origin by extracting relevant data from the literature [77].

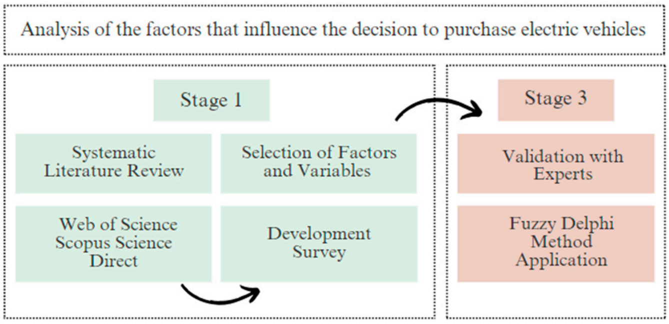

Figure 3. Stages of the methodology.

The first phase of the study consisted of a systematic literature review (SLR) to identify the main factors and variables that can influence the decision to buy an EV. The search was carried out in the Web of Science, Scopus, and Science Direct databases, using the keywords "purchase" and "electric vehicle", and the analysis was restricted to publications from 2018 to 2022.

After selecting the factors and variables through the systematic literature review (SLR), the next step was to draw up a questionnaire to be validated by experts. This phase aims to validate the results of the SLR and measure the performance of the criteria relating to personal, economic, environmental, psychological and performance factors. Once the factors and variables had been selected through the SRL, the elements were then incorporated into the design of the data collection instrument. The instrument was validated by experts using the fuzzy Delphi method.

4. Results—Systematic Literature Review

To understand the position of the literature about buying electric vehicles in an international context, the systematic literature review (SLR) was conducted on the Web of Science, Scopus, and Science Direct databases. Zotero version 6.0 software was used to catalogue the files, assisted by VOSviewer version 1.6.19 software and Bibliometrix to identify the relationships between the articles.

To determine the keywords used in the database searches, queries and tests were conducted. The central theme of the research was the purchase of electric vehicles, with the analysis restricted to publications from the last five years (2018–2022). These databases were chosen due to their extensive use by researchers and the presence of high-impact papers [78]. Figure 4 shows the stages and selection of the articles used in this study.

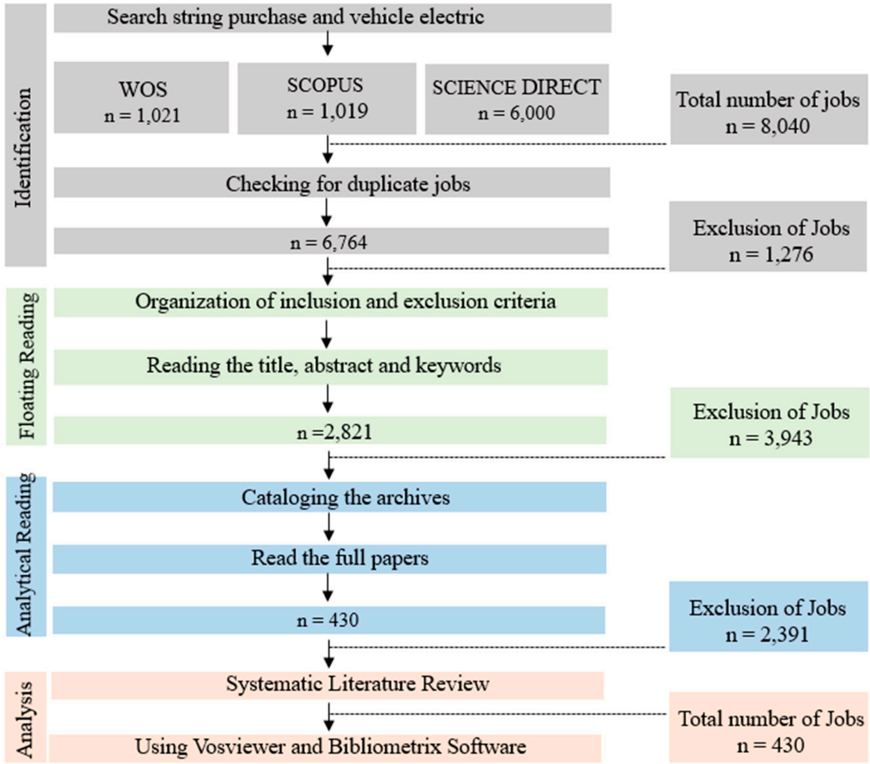

Figure 4. Stages of the systematic literature review.

A checklist was used to catalogue the files found in the databases and map out the selection of literature. Initially, all the articles related to this study were identified using the keywords in the databases. Subsequently, a floating reading was carried out, in which the titles, keywords, and abstracts were assessed. Papers that did not meet the established criteria were excluded. An analytical reading was then carried out to assess the articles in their entirety, checking whether they were related to the subject of this study.

Based on these steps, the aim of this study was to identify the factors that influence consumers when buying EVs. Using keywords from the WOS, Scopus, and Science Direct databases in the period mentioned above, 8040 publications were catalogued. The floating reading process excluded papers that were not related to the topic, totalling 2821 articles. After this stage, with the analytical readings (more in-depth analysis of the materials), 430 final papers were selected. This made it possible to identify the main information related to the evolution of this area from 2018 to 2022.

Figure 5 shows the evolution of the topic of buying electric vehicles, highlighting an increase of 11 publications from 2018 to 2019, followed by a drop of 7 publications in 2020. The growth since 2018 may be associated with the political incentives that have been implemented to encourage consumers to buy electric vehicles, which has led to an increase in research into various scenario analyses [79].

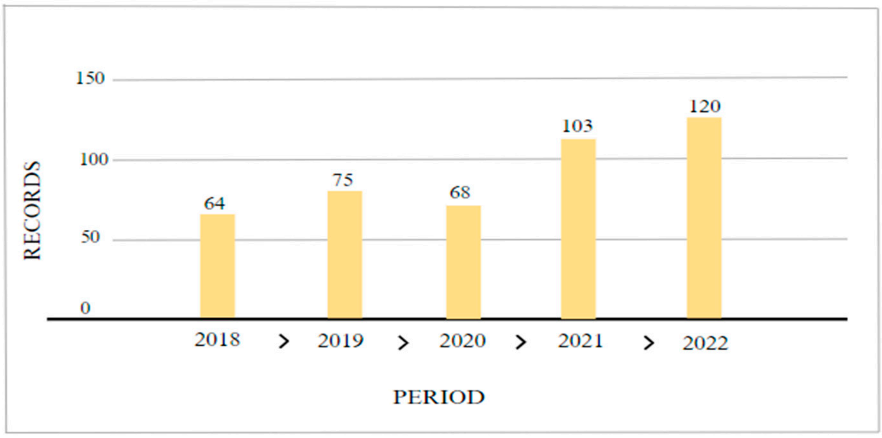

Figure 5. Evolution of the electric vehicle purchasing theme.

In addition to incentives, draft laws related to electromobility have also been created, as is the case in Brazil. In 2017, Bill No. 454/2017, which proposed a ban on the sale of new cars powered by combustion engines as of 1 January 2060 [51], was being processed in the Federal Senate; however, in December 2022, the proposal was shelved.

Regarding the 2022 period, information was collected up to the middle of December, showing an increase of 17 publications. This demonstrates a clear trend towards the evolution of the theme in research related to the purchase of electric vehicles.

In addition to the increase in publications in the area, using the VOSviewer software, it was possible to analyse the most frequently used terms in the subject. Figure 6 shows the grouping of terms into three clusters, as indicated by the colour of the lines. The words in the red cluster are related to the theme of buying electric vehicles and the incentives for adopting electromobility. In the green cluster, consumer attitudes stand out, relating to factors such as technology, planning, and barriers to the acquisition of electric vehicles.

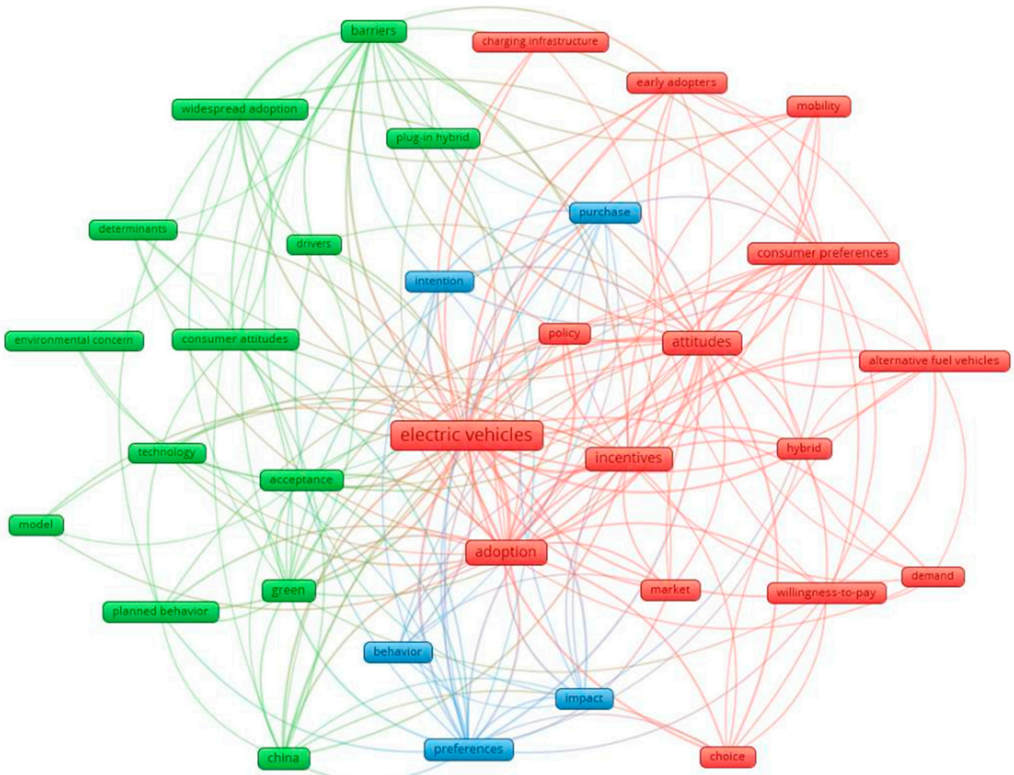

Figure 6. Main keywords of the electric vehicle purchasing theme.

The blue cluster shows consumer attitudes, highlighting consumer preferences, purchase intentions, and impacts on the purchase of electric vehicles. The five words that stand out most in scientific research on the subject are "electric vehicles", "adoption", "purchase", "attitudes", and "preferences". This shows that the studies are related to the adoption of electric vehicles, analysing the factors that drive the purchase of these vehicles, as well as understanding consumer preferences.

The high number of occurrences of these keywords was expected, since the filter used to search the database contained these terms. However, it is interesting to note that the words "incentives", "attitudes", and "preferences" were also prominent. The year 2022 saw an increase in topics related to consumers' purchasing intentions. This is due to the evolution of studies and the diversification of new vehicle technologies on offer, which has increased the possibilities for potential new users.

In addition to the most used keywords, the analysis conducted in the Bibliometrix package made it possible to identify which journals have the most publications on the subject. In this way, "Sustainability", "Transportation Research", "Energy Policy" and the "Journal of Cleaner Production" stand out, highlighting the relevance of the research that these journals publish.

Figure 7 shows the ten countries with the most research on this subject. In this context, China stands out in terms of research on this subject, with the highest frequency. In second place is the United States, followed by India, demonstrating that the Asian continent is home to several studies in this area, so there is an expansion of knowledge to promote progress in this area.

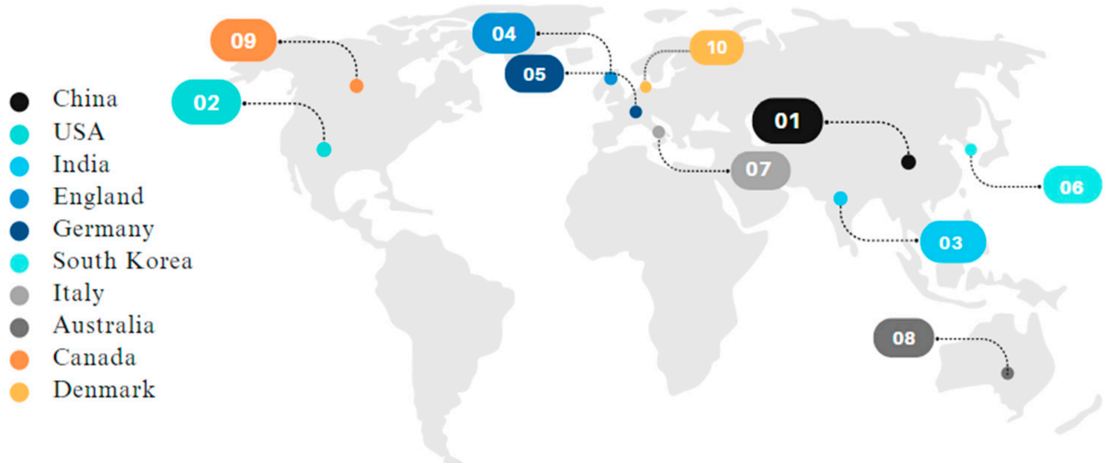

Figure 7. Ten countries with the highest number of publications on the topic of EV purchases.

After obtaining the country data, an analysis of the authors was conducted using VOSviewer, as shown in Figure 8. The authors who stand out in investigating the purchase of electric vehicles present a grouping of three clusters:

- Blue cluster (3 authors): Hardman, S.; Tal G.; Axsen, J.
- Red cluster (11 authors): Fan, Y.; Zhang G.; Wang H.; Zhuge C.; Zhang Q.; Li, W; Higueras-Castillo E.; Wang Y.; Wang J.; Wang Z.; Huang Y.; Wang S.
- Green cluster (4 authors): Sovacool, K.; Noel L.; Kester, J.; de Rubens, G.

For a joint analysis of the factors, the 3-field chart provided by Biblioshiny was used. Figure 9 shows the cross-referenced information from the research, with the twelve countries with the highest number of publications, the institutions with the most publications on the subject, and the most used keywords. The size of each rectangle shows the number of publications associated with the area, so you can see each existing connection through the grey connections.

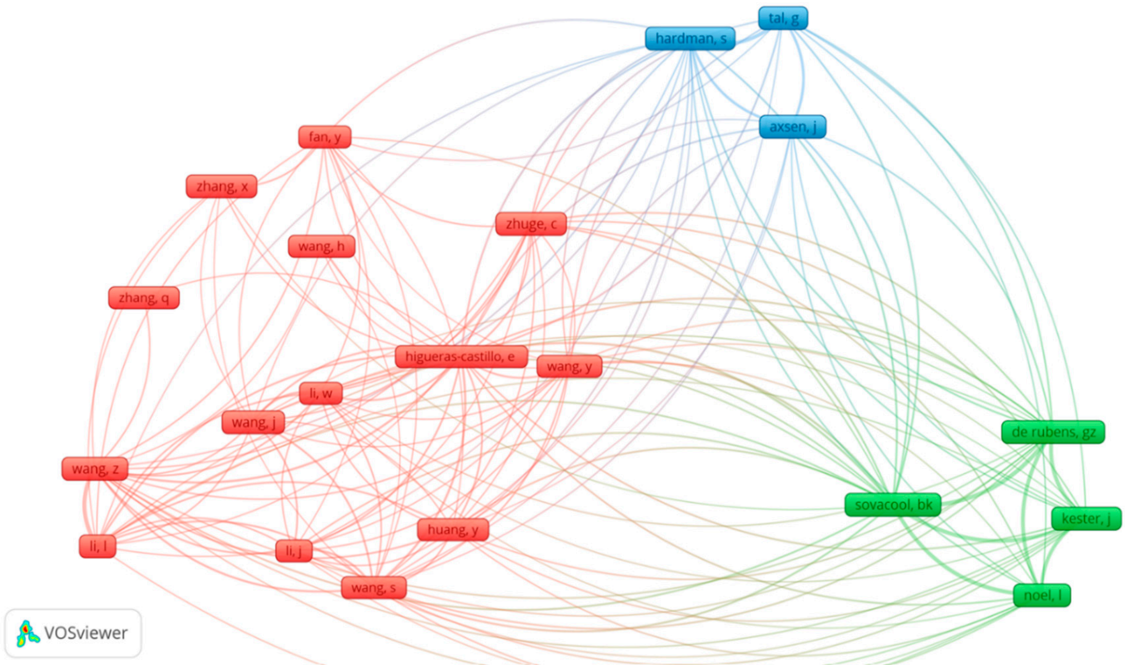

Figure 8. Main authors writing about electric vehicle purchasing.

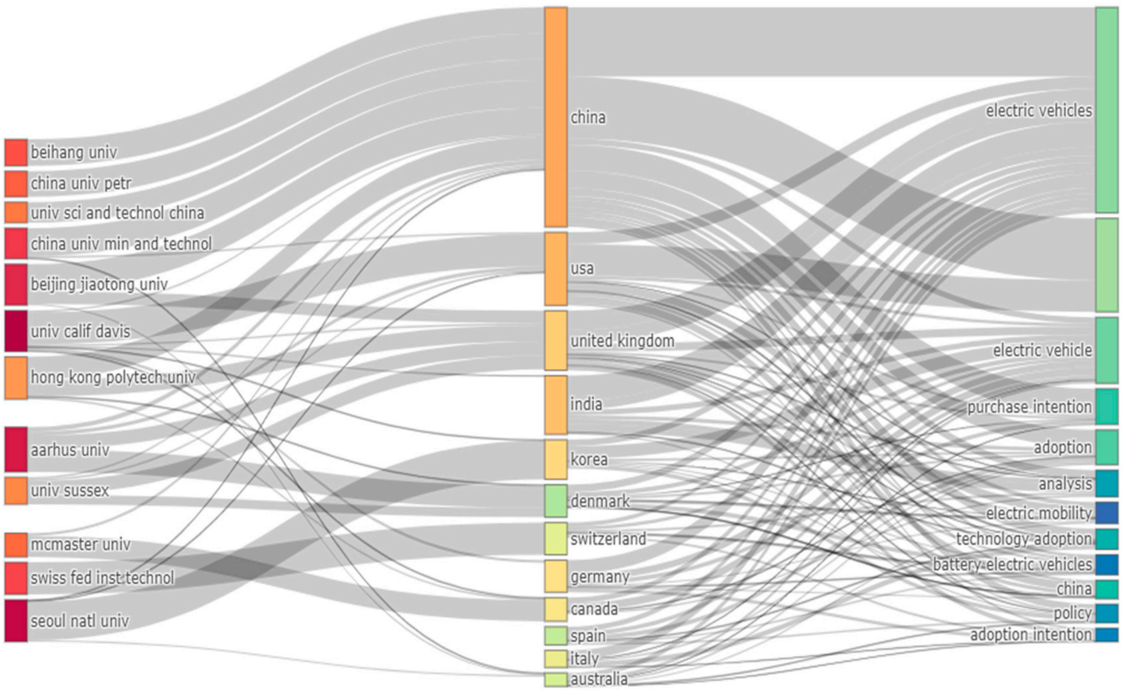

Figure 9. 3-field graph between institutions, countries and keywords.

In the graph, the main area refers to the countries with the highest number of publications, with China and the United States standing out, as has been shown in previous analyses carried out by VOSviewer. On the left-hand side of the graph are the main institutions with the highest number of publications on the subject, with Aarhus University standing out. On the right, the most used keywords are shown, with "electric vehicles" being the main word, while the other keywords refer to terms related to purchase intention and adoption.

With regard to countries, the publications by Chinese authors are linked to 10 keyword topics, with the main ones being "electric vehicles" and "adoption". These same topics are also the most used in the United Kingdom, demonstrating the progress of research on this subject. On the other hand, the United States has a greater relationship with the keywords "electric vehicles" and "technological adoption". Both countries share a connection with the University of Aarhus. The institutions that stand out most in terms of the number of journals are Beijing Institute of Technology, Beihang University, and Beijing Jiaotong University, respectively.

Factors for making the decision to buy electric vehicles were observed, as well as the context of the main variables in this process. There was a need to assess the perception of experts about the main factors for making the decision to buy EVs to validate the results of the SRL, as well as measure the performance of the criteria related to personal, economic, environmental, psychological, and performance factors. The variables, listed and presented as questions within the questionnaire, were organised into thematic blocks, as shown in Figure 10.

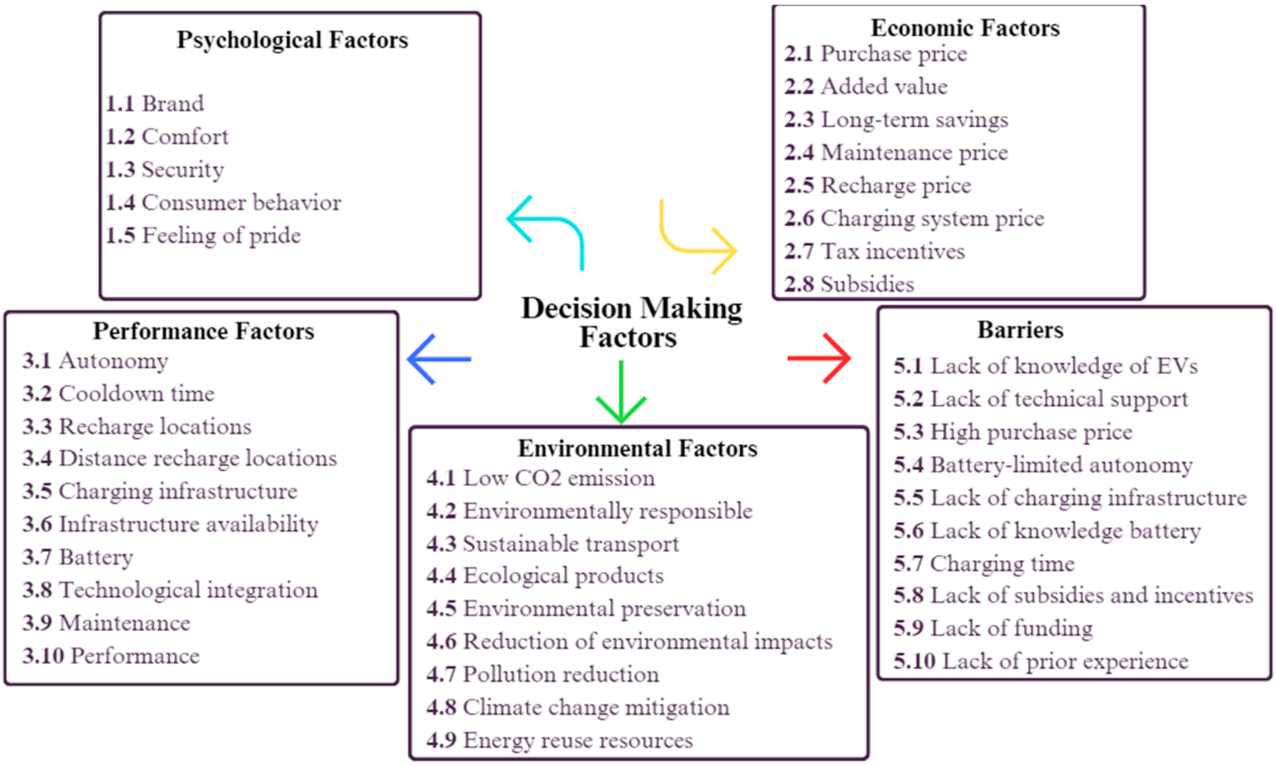

Figure 10. Structure of the data collection instrument of the quantitative stage.

Table 2 highlights the researchers whose work served as the basis for choosing the factors and variables associated with the purchase of electric vehicles. In addition to the six blocks described above, personal factors were analysed, with information on age, gender, and income, among others. However, the variables associated with this factor were not included for validation in the fuzzy phase, as they were personal responses from the respondents.

Table 2. Factors and variables associated with the systematic literature review.

Factor	Variables	Authors
Psychological	Buy Intention	[14,16–18,20–22,25,26,28,32,34–37,79–96]
	Perceived Risk	[14,16,19–21,25,26,30,35,36,79,93,97]
	Consumer Characteristics	[14,17,19,21,22,26,30,32,34–36,79,82,85,87,89,90,92,93,95,98]
	Emotion	[14,18–21,26,30,34–36,97–99]
Economic	Electric Vehicle Price	[20–22,25,26,30,32,35–37,82,84–87,90,94–107]
	Electricity Price	[14,22,25,26,30,81,86,95–97,103,104,106–111]
	Price Maintenance (service)	[20–22,25,26,30,36,86,97,98,102,105,107,111]
	Fuel Price	[21,26,28,30,36,86,96–98,101–109]
	Subsidies	[14,19,21,22,26,30,32,35,36,79,81,84,86,90,95–97,100,102,104–111]
	Tax Incentives	[14,19,21,22,26,30,32,35,36,79,84,86,88,90,95–97,100,102,105–109,111]
Environmental	Zero Emissions	[21,26,30,34–36,79,83,84,87,88,94,98,100,102,103,105,107,108,112]
	Environmental Regulation	[21,25,26,30,34–36,79,80,83,88,97,102,105,108,112,113]
	Sustainability	[14,20,21,25,26,28,30,32,34–36,79–83,85–87,89,90,92–94,98–100,102,103,105,107–110,112,113]
	Environmental Performance	[21,26,28,30,32,34–36,79,80,83,85,86,88,93,99,100,102,103,105,108,109,112,113]
Performance	Performance	[13,25,28,30,35,87,92,94,97,107]
	Autonomy	[13,20,26,28,30,35–37,81,86,87,89,94,95,97,100,107]
	Engine	[13,26,30,35,36]
	Battery	[16,20,21,25,28,30,36,74,87,89,94,97]
	Technology	[13,14,20,30,35,36,84,86,87,89,92–94,97,106,111,112]
	Charging Time	[13,20,21,25,26,28,30,35–37,80,81,83,84,86,87,89,95,97,100,102,106,107,109–111]
	Charging Infrastructure	[13,14,20,21,25,26,28,30,35–37,81,83,84,86,87,94,95,97,100,102,104,106,109–112]
Personal	Sex	[14,16,18,20,22,26,28,30,32,34,35,79,80,82,83,85–87,89–91,93,94,96,99,102,105,113]
	Age	[14,16,18,20–22,26,28,30,32,33,79,80,82,83,85–87,89–91,93,94,96,97,102,105,113]
	Profession	[16,18,20–22,26,30,35,79,83,87,91,96,102,105]
	Education	[16,18,21,22,26,30,32,34,35,79,80,82,83,85–87,91,96,99,102,105,113]
	Demographic	[14,16,18,21,26,28,30,34,35,79,83,87,89,91,93,94,96,102,105]
	Income	[14,16,18,21,22,26,28,30,32,34,35,79,80,83,85–87,90,91,94,96,99,102,105,113]
Barriers	-	[25,35,85,86,97,114–127]

Source: Authors (2024).

5. Results—Fuzzy Delphi

The fuzzy Delphi method integrates qualitative and quantitative approaches by having participants answer the survey questionnaire on a single occasion. This approach aims to minimise the number of respondents and the time dedicated to the survey, with a recommended number of respondents between five and twenty [128].

Based on this information, the instrument used a 5-point Likert scale to measure the respondents' level of interest, based on the following: 1—Almost no interest; 2—Little interest; 3—Medium interest; 4—Great interest; 5—Extremely great interest. To validate this stage, 35 experts were invited in the period of September 2023, all of whom held a doctorate and worked as researchers. However, 23 experts took part, distributed as follows: 12 in the global south, 4 in the central–west, 4 in the southeast, and 2 in the north.

To apply the method, it was necessary to identify the criteria and the number of experts, and then convert the answers for each criterion into fuzzy numbers (triangular fuzzy number—TFN) [129].

Score 1 (0.1; 0.1; 0.3);
Score 2 (0.1; 0.3; 0.5);
Score 3 (0.3; 0.5; 0.7);
Score 4 (0.5; 0.7; 0.9);
Score 5 (0.7; 0.9; 0.9).

The fuzzy value corresponding to the j-th criterion provided by the i-th expert is represented in (1), and the fuzzy weights of the criteria are outlined in (2)–(4). Finally, the fuzzy weight is averaged to calculate the defuzzification (5), where n = number of specialists and m = the number of criteria.

$$\tilde{a}ij = (aij, bij, cij) \text{ para } i = 1, 2, 3 \ldots nj = 1, 2, 3 \ldots m \quad (1)$$

$$aj = \min \{aij\} \quad (2)$$

$$bj = (\prod i = 1n \ bij)1/n \quad (3)$$

$$cj = \max \{cij\} \quad (4)$$

$$\tilde{a}j = \frac{aj + bj + c}{3} = 1, 2, 3 \ldots m \quad (5)$$

As an example, for variable 1.1 (Brand), expert 1 gave a rating of "3", whose TFN is (0.3; 0.5; 0.7). In the same way, the TFN of each rating given by the 23 experts in relation to variable 1.1 was found, as shown below:

Specialist 1—(0.3; 0.5; 0.7) [note 3];
Specialist 2—(0.5; 0.7; 0.9) [note 4];
Specialist 3—(0.5; 0.7; 0.9) [note 4];
Specialist 4—(0.5; 0.7; 0.9) [note 4];
Specialist 5—(0.5; 0.7; 0.9) [note 4];
Specialist 6—(0.3; 0.5; 0.7) [note 3];
Specialist 7—(0.5; 0.7; 0.9) [note 4];
Specialist 8—(0.7; 0.9; 0.9) [note 5];
Specialist 9—(0.5; 0.7; 0.9) [note 4];
Specialist 10—(0.5; 0.7; 0.9) [note 4];
Specialist 11—(0.3; 0.5; 0.7) [note 3];
Specialist 12—(0.7; 0.9; 0.9) [note 5];
Specialist 13—(0.5; 0.7; 0.9) [note 4];
Specialist 14—(0.7; 0.9; 0.9) [note 5];
Specialist 15—(0.7; 0.9; 0.9) [note 5];
Specialist 16—(0.5; 0.7; 0.9) [note 4];
Specialist 17—(0.7; 0.9; 0.9) [note 5];
Specialist 18—(0.3; 0.5; 0.7) [note 3];
Specialist 19—(0.3; 0.5; 0.7) [note 3];
Specialist 20—(0.3; 0.5; 0.7) [note 3];
Specialist 21—(0.5; 0.7; 0.9) [note 4];
Specialist 22—(0.5; 0.7; 0.9) [note 4];
Specialist 23—(0.5; 0.7; 0.9) [note 4];

The fuzzy weight for variable 1.1, expressed as (0.3; 0.7; 0.9), was determined as follows. The first entry of the fuzzy weight, i.e., 0.3, was obtained from the minimum value among all the first 23 entries mentioned above, i.e.,:

Min (0.3; 0.5; 0.5; 0.5; 0.5; 0.3; 0.5; 0.7; 0.5; 0.5; 0.3; 0.7; 0.5; 0.7; 0.7; 0.5; 0.7; 0.3; 0.3; 0.3; 0.5; 0.5; 0.5) = 0.3;

The next fuzzy weight entry, i.e., 0.7, was calculated by taking the geometric mean of the geometric means of all the second 23 entries provided previously, i.e.,: (0.5 × 0.7 × 0.7 × 0.7 × 0.7 × 0.5 × 0.7 × 0.9 × 0.9 × 0.7 × 0.7 × 0.5 × 0.9 × 0.7 × 0.9 ×

〖0.9 × 0.7 × 0.9 × 0.5 × 0.5 × 0.5 × 0.7 × 0.7 × 0.7)〗^(1/23) = 0.7

The third input of the fuzzy weight, i.e., 0.9, was determined by selecting the maximum value among all the 23 third inputs mentioned above, i.e.,:

Max (0.7; 0.9; 0.9; 0.9; 0.9; 0.7; 0.9; 0.9; 0.9; 0.9; 0.7; 0.9; 0.9; 0.9; 0.9; 0.9; 0.9; 0.7; 0.7; 0.7; 0.9; 0.9; 0.9) = 0.9.

Similarly, the process of obtaining the fuzzy weight was determined for all 48 variables. The defuzzification value for each variable was obtained by averaging the fuzzy weight (according to Equation (5)). As an example, the defuzzification value for variable 1.1, with a fuzzy weight of (0.3, 0.7, 0.9) is obtained as (0.3 + 0.7 + 0.9)/3, which is "0.6", as shown in Table 3. The threshold ã is established to select or reject the factors, being defined by the average between the minimum value of the linguistic variable "important" (0.5) and the maximum value of the linguistic variable "indifferent" (0.7), resulting in ã = 0.6. And the principle to select or reject the criterion is as follows: if ã*j* ≥ ã, then criterion j is selected, while if ã*j* < ã, then criterion j is rejected [14].

Table 3. Expert analysis result.

Block	Factors	Variables	Aj	Bj	Cj	TFN	Value Fuzzific.	Decision
I	Psychologic	1.1	0.3	0.7	0.9	(0.3; 0.7; 0.9)	0.6	SELECTED
		1.2	0.3	0.7	0.9	(0.3; 0.7; 0.9)	0.6	SELECTED
		1.3	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		1.4	0.3	0.7	0.9	(0.3; 0.7; 0.9)	0.6	SELECTED
		1.5	0.1	0.6	0.9	(0.1; 0.6; 0.9)	0.5	REJECTED
II	Economic	2.1	0.5	0.8	0.9	(0.5; 0.8; 0.9)	0.7	SELECTED
		2.2	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		2.3	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		2.4	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		2.5	0.1	0.8	0.9	(0.1; 0.8; 0.9)	0.6	SELECTED
		2.6	0.1	0.8	0.9	(0.1; 0.8; 0.9)	0.6	SELECTED
		2.7	0.1	0.8	0.9	(0.1; 0.8; 0.9)	0.6	SELECTED
		2.8	0.5	0.8	0.9	(0.5; 0.8; 0.9)	0.7	SELECTED
III	Performance	3.1	0.1	0.7	0.9	(0.1; 0.7; 0.9)	0.6	SELECTED
		3.2	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		3.3	0.5	0.9	0.9	(0.3; 0.9; 0.9)	0.8	SELECTED
		3.4	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		3.5	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		3.6	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		3.7	0.5	0.8	0.9	(0.5; 0.8; 0.9)	0.7	SELECTED
		3.8	0.1	0.7	0.9	(0.1; 0.7; 0.9)	0.6	SELECTED
		3.9	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		3.10	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED

Table 3. *Cont.*

Block	Factors	Variables	Aj	Bj	Cj	TFN	Value Fuzzific.	Decision
IV	Environmental	4.1	0.1	0.7	0.9	(0.1; 0.7; 0.9)	0.6	SELECTED
		4.2	0.1	0.7	0.9	(0.1; 0.7; 0.9)	0.6	SELECTED
		4.3	0.1	0.7	0.9	(0.1; 0.7; 0.9)	0.6	SELECTED
		4.4	0.1	0.7	0.9	(0.1; 0.7; 0.9)	0.6	SELECTED
		4.5	0.3	0.7	0.9	(0.3; 0.7; 0.9)	0.6	SELECTED
		4.6	0.3	0.7	0.9	(0.3; 0.7; 0.9)	0.6	SELECTED
		4.7	0.3	0.3	0.9	(0.3; 0.7; 0.9)	0.7	SELECTED
		4.8	0.1	0.7	0.9	(0.1; 0.7; 0.9)	0.6	SELECTED
		4.9	0.3	0.3	0.9	(0.3; 0.3; 0.9)	0.7	SELECTED
V	Barriers	5.1	0.1	0.5	0.9	(0.1; 0.5; 0.9)	0.5	REJECTED
		5.2	0.1	0.8	0.9	(0.1; 0.8; 0.9)	0.6	SELECTED
		5.3	0.3	0.9	0.9	(0.3; 0.9; 0.9)	0.7	SELECTED
		5.4	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		5.5	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		5.6	0.1	0.5	0.9	(0.1; 0.5; 0.9)	0.5	REJECTED
		5.7	0.3	0.8	0.9	(0.3; 0.8; 0.9)	0.7	SELECTED
		5.8	0.1	0.7	0.9	(0.1; 0.7; 0.9)	0.6	SELECTED
		5.9	0.1	0.6	0.9	(0.1; 0.6; 0.9)	0.5	REJECTED
		5.10	0.1	0.5	0.9	(0.1; 0.5; 0.9)	0.5	REJECTED

Of the 42 variables initially selected based on the SLR, 5 variables were eliminated because ãj was less than 0.6 (ã). In the first block, the only variable discarded was (1.5), which relates to the individual's sense of pride when purchasing a vehicle. In blocks two, three, and four, none of the variables were rejected. In the fifth block, variables 5.1, 5.6, 5.9, and 5.10 were eliminated since ãj was less than 0.6 (ã).

Some of the variables surveyed in the SRL on the purchase of EVs, as perceived by experts in Engineering, Management, and Technology, who have experience in both academia and the market, are classified as having low applicability. This applicability can be attributed to the influence of the experts' perception of the factors considered in their professional experience of buying vehicles. It should also be noted that the experts selected were from different regions of the world.

When analysing the relative importance of the factors, there was a significant emphasis on the variables related to the performance factor, especially variable 3.3, related to recharging locations. This is particularly relevant in the Brazilian context, where charging infrastructure for electric vehicles is still a concern for future users of this type of vehicle. About psychological factors, the variable selected that stood out the most was safety. This shows the importance that future consumers attach to the feeling of protection when considering adopting electric vehicles. However, some of the statements were removed because they were less important than others and could be ranked more highly at another point in the survey.

6. Conclusions

This study looked at the main journals, countries, authors, and keywords on the subject of buying electric vehicles through a systematic literature review (SRL) in the Web of Science, Scopus, and Science Direct databases from 2018 to 2022. The aim of this study was to identify the main variables in the electric vehicles purchase decision according to the perception of experts, using the fuzzy Delphi method.

In the bibliographic mapping process, floating reading strategies were adopted, in which titles, keywords, and abstracts were analysed, excluding works that did not align with the established criteria. Subsequently, analytical reading was conducted to evaluate the articles in their entirety, checking whether they were related to the theme of this study. Based on these steps, the main objective of this research was to identify the factors that influence consumers in their purchase decision, through the perception of experts using the fuzzy Delphi method. A total of 8040 publications were catalogued. During the floating reading phase, 2821 papers that were not related to the topic were excluded. After this stage, the analytical readings resulted in the selection of 430 final papers.

The results show that thirty-seven variables, initially selected through a SLR, were validated using the fuzzy Delphi method. These variables were grouped into five blocks: five in the first block, dealing with psychological factors; ten variables in performance factors; nine variables in environmental factors; and ten variables referring to barriers.

After the experts validated the variables, the initial questionnaire was adapted. This adjustment was made for the next stage of this research, which involved applying the questionnaire to the general population, with the aim of identifying the main variables in the EV purchase decision in Brazil.

The review showed that the topic of buying electric vehicles has evolved. The growth since 2018 may be associated with political incentives and the creation of bills designed to encourage consumers. In addition to the increase in publications in the area, the most frequently used terms were grouped together, including "purchase of electric vehicles" and "incentives" to adopt electromobility.

In addition to the most used keywords, the analysis made it possible to identify the journals with the most publications on the subject. In this way, the following stand out: "Sustainability", "Transportation Research", "Energy Policy", and the "Journal of Cleaner Production", highlighting the relevance of the research that these journals publish. With regard to the countries with the highest volume of research on the subject, China and the United States emerge as the most prolific.

Considering the above, there has been a significant increase in the search to investigate and analyse information related to the purchase of electric vehicles in recent years. The study of factors and variables that can influence the purchase of these vehicles is extremely important, as it makes it possible to implement more effective public policies.

In this context, a factor of great relevance is associated with the purchase price, which ends up influencing consumers during the acquisition process [71]. However, in recent years, there has been a change in consumer opinion, and other factors are also being highlighted. One of these factors is environmental performance, as consumers are increasingly seeking to adopt more environmentally conscious measures [23].

In addition, other factors that can still be considered as obstacles to the purchase of EVs include charging times, autonomy, and the density of charging stations [74]. Listing the factors helps to target investments more precisely, attracting new users and guaranteeing a future market for this type of vehicle.

The results of the survey show the potential of the electric vehicle market, as sales have grown steadily in recent years in several countries. This highlights the need for incentives and regulation to further expand this market. A limitation of this study is the opinions of the experts involved, as another group of participants could consider different weights for the variables, potentially resulting in divergent conclusions. Future studies suggest expanding the study through an international survey, allowing for a more comprehensive understanding of perceptions and trends in different geographical contexts. In addition, the adoption of machine learning methods for comparative data analysis could provide important information, allowing patterns to be identified that are not easily discernible through traditional methods.

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