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Review

Electric Vehicle Supply Chain Management: A Bibliometric and Systematic Review

Laene Oliveira Soares [1,2], Augusto da Cunha Reis [2], Pedro Senna Vieira [2], Luis Hernández-Callejo [3,*] and Ronney Arismel Mancebo Boloy [1,2,*]

[1] Group of Entrepreneurship, Energy, Environment and Technology–GEEMAT, Rio de Janeiro 20271-204, Brazil
[2] Federal Centre of Technological Education Celso Suckow da Fonseca (CEFET/RJ), Rio de Janeiro 20271-204, Brazil
[3] Department of Agricultural Engineering and Forestry, Universidad de Valladolid, Campus Universitario Duques de Soria, 42004 Soria, Spain
* Correspondence: luis.hernandez.callejo@uva.es (L.H.-C.); ronney.boloy@cefet-rj.br (R.A.M.B.)

Abstract: With the advancement of electric mobility, critical materials that are used in the batteries and electronic equipment of electric vehicles tend to become scarce. This work aims to analyse the state-of-art of the electric vehicle supply chain through bibliometric and systematic reviews, using quantitative and qualitative indicators, to find critical points that represent risks to the supply chain and that should be focused on and to identify trends for further studies. The bibliometric review was carried out with the support of the Bibliometrix software. The systematic review was performed using the PRISMA method. The bibliometric analysis showed the importance of the costs associated with electric vehicles, as well as trends in studies related to sustainability and transparency in the supply chain. Although risk management in the supply chain appears to be relatively little studied when considering the authors' keyword analysis, the systematic review showed that this process was the most studied topic. Even so, raw materials supply appeared as the topic most focused on, followed by an environmental impact assessment and cost analysis. There were also studies aiming to achieve competitiveness and analyse ecologically correct practices. The battery was the most studied component, but other components must be analysed in search of greater competitiveness in relation to conventional vehicles.

Keywords: supply chain management; PRISMA; bibliometric analysis; systematic review

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1. Introduction

Hybrid electric vehicles rely on a combination of electricity and fuel combustion to power the battery and the internal combustion engine, respectively. Thus, considering the use of electricity generated from renewable energies and the use of biofuels, for example, hybrid vehicles, with or without a plug, can be seen even more as an alternative for reducing emissions. Some electric vehicles are already in circulation in Brazilian fleets, such as hybrid vehicles (Toyota RAV4 SX Connect Hybrid, Toyota Prius Hybrid, Toyota Corolla Altis Hybrid), battery electric vehicles (Renault Zoe E-Tech, Nissan Leaf) and plug-in hybrid vehicles (MINI Cooper S E Compatriot ALL4).

However, this growth can result in environmental impacts caused by several electric vehicle supply chains, mainly by the production of batteries [1]. Elements such as cobalt, lithium, and nickel are constituents of the lithium-ion batteries mainly used in electronics and electric vehicles [2]. To reduce emissions and the demand for inputs, attention must be paid to the availability of raw materials and the optimization of the supply chain, encouraging the recycling of critical chemical components for the production of new batteries, and avoiding the inappropriate disposal of these elements in the environment.

In this study, the electric vehicle supply chain is analysed through a combined bibliometric and systematic review to identify the focus of studies related to this topic and researchers' concerns regarding environmental pollution and demand risks. A bibliometric review is a type of review that quantitatively analyses published studies according to bibliometric indicators, such as the number of publications and occurrences of keywords, identifying trends in a subject. In addition, the use of keywords in the bibliometric analysis allows for exploring study details found in specific research topics [3]. On the other hand, this analysis has disadvantages such as the influence of the chosen indicators on the results. Other limitations include the need to find a comprehensive database and fact that the author tends to be biased in the selection of articles to be analysed. The systematic review differs from the bibliometric review because it seeks to qualitatively analyse existing studies in the literature. Through this review, it is possible to identify and select relevant studies and collect and analyse their content [4]. However, systematic review conclusions vary depending on how clear the reports were, what research was undertaken and what was found, resulting in limitations in the review's ability to identify the strengths and weaknesses of the analysed studies [4]. From these analyses, results can be found to explain a particular focus and gap in the literature. In this work, both types of reviews were integrated to allow a complete analysis of what was studied and how, and to compare the conclusions that both reviews can provide, with the aim of demonstrating that different paths can be taken if analysing the studies quantitatively and/or qualitatively.

The PRISMA method was used to complement the systematic analysis and to answer some elaborated questions, to analyse what was studied and identify the focus of the researchers. This method consists of a four-phase process: (i) Identification, (ii) Screening, (iii) Eligibility and (iv) Included. In the Identification phase, the topic to be researched and the database are chosen, allowing the inclusion of documents from other databases. Exclusion and inclusion criteria are presented in detail in the Screening phase, finding targeted and specific search results. For the Eligibility phase, it is necessary to read the articles selected in the previous phase, and the excluded articles, if any, must be accompanied by justifications and explanations. Finally, the documents that meet the criteria of the previous phases are added to the Included phase, which are the studies included in the meta-analysis [4].

The bibliometric review had as its main focus the evaluation of the availability of electric vehicle battery components [5,6]. With the concern to mitigate emissions, the deployment of electric vehicles and the demand for chemical components grow proportionally. In addition, charging methods were recently analysed in bibliometric works, through theoretical study and application of improvements in charging stations [7,8].

The systematic review was applied to several recent studies related to electric mobility that focus mainly on batteries and the energy required. An analysis of smart contracts used in the energy sector was presented, pointing out their strengths and weaknesses through a systematic review [9]. One of the recommendations is to strengthen the cybersecurity of smart contracts and carefully consider the cost of their implementation and deployment. A systematic review of the electric vehicle charging infrastructure was carried out, analysing the integrated energy transport and distribution network since, according to the authors, it is necessary to implement efficient charging stations to support the adoption of large electric vehicles [10]. Among the gaps found is the need to combine different types of loading instead of considering only fast loading and to improve the approach and planning theories presented by transforming them into case studies. However, a PRISMA analysis conducted in a recent study on consumer concern and behaviour regarding the use of battery electric vehicles found that many studies do not provide details about their work, making it difficult to understand the evidence to replicate the studies and build facilitators in the area [11].

Studies which applied the PRISMA method were found in several areas of research. For instance, ways to solve problems related to energy management were discussed using this method, aiming to guide plans of decision makers based on multi-criteria decision-making methods [12]. The authors of [13] conducted a study combining bibliometric and systematic reviews to analyse the state-of-art of renewable energy generation through distinct solid wastes. Nonetheless, to date, no scientific work has been published combining bibliometric and systematic reviews specifically focused on the electric vehicle supply chain sector to identify its strengths and weaknesses. To fill this gap, this work aims to analyse the state-of-art of the electric vehicle supply chain through both reviews, based on quantitative and qualitative analysis using the Bibliometrix software and the PRISMA method, respectively. The work aims to find critical points that can cause risks to the supply chain that should be focused on, and identify trends for further studies. In addition, the electric vehicle supply chain was analysed considering the pre- and post-scenarios of the COVID-19 pandemic.

2. Materials and Methods

The analysis conducted in this work was based on documents found in the Scopus database through the following string: TITLE-ABS-KEY ((“electric vehicle*”) AND (“supply chain” OR “supply chain management” OR “supply chain risk management” OR “supply chain resilience”)). After comparing results with the Web of Sciences—Analytics Clarivate database, Scopus was chosen due to the fact that it is a relevant database, with studies published in indexed journals with high impact factors and is one of the most complete databases in this specific area. Based on the string used, 545 documents were found. Filters were chosen to select only articles written in English and those published between 2018 and 2022, articles labelled as open access, and those whose content could be fully accessed without limitations, resulting in 105 articles. In this study, the bibliometric and systematic reviews were conducted together, aiming to present a more in-depth analysis of the supply chain management of the electric vehicle sector.

2.1. Bibliometric Review

A bibliometric review seeks to quantify published studies on a specific topic, highlighting what is known and the trends for new studies. This provides researchers and government agencies with a direction to follow in the development of studies and decision-making. In this study, the bibliometric analysis was carried out with the support of the Bibliometrix software to map the focus and trends of studies on electric vehicle supply chain management. This review was based on the six most used indicators in bibliometric review studies. They were chosen to analyse trends related to cooperation and subjects and to assist further studies on journal selection. The indicators included were (a) partnerships between countries [13,14]; (b) co-occurrence of the authors’ keywords [13,15]; (c) publications per year [13,15–17]; (d) publications by country [13,15,16]; (e) impact factor of journals [15,18]; and (f) areas of research [17].

2.1.1. Partnership between Countries

This indicator aims to identify global concrete links and propose links between countries that do not have collaboration but have potential in exploring or implementing a process, system, or product [19,20]. Interests between countries can also be discussed. Both attractions and links, strong or non-existent, were identified, and new collaborations were proposed.

2.1.2. Co-Occurrence of the Authors’ Keywords

Trends and findings of gaps in the literature can be analysed using the authors’ keywords or keywords provided by the database [20–22]. The latter are labelled as ‘Keyword Plus’ in the Web of Science database or ‘Index Keyword’ in the Scopus database. The difference between them is in the specificity. The keywords provided by the database are more comprehensive, containing words found in cited references but not found in the article [23]. For example, in an investigation, a reference may be used only to contextualize the topic, but the topic is not addressed in the main text of the paper, making the keyword retrieved from this reference inconsistent with the subject sought. On the other hand, the authors add the authors’ keywords to describe the topic more specifically, facilitating a more in-depth analysis of the literature. Thus, in this study, the authors’ keywords were analysed.

2.1.3. Publications Per Year

The number of articles published in a specific period can be analysed to support the analysis of trends and findings [20–22]. The phenomena presented in the publications graph were identified and interpreted to understand the starting point that leveraged research related to the supply chain of electric vehicles.

2.1.4. Publications by Country

The interest of a country in each subject can be assessed by analysing the number of publications on a national basis [20–22,24]. From this indicator, it is possible to identify, for example, whether the country's interest is to advance in local development or to export its optimized products or services.

2.1.5. Impact Factor of Journals

This is an indicator to identify the most relevant journals for the proposed topic [21,22,24], helping mainly in forwarding future works and optimizing the publication period since the submission of articles that meet the scope of the chosen journal is one of the reasons for the delay in publications.

2.1.6. Areas of Research

Each published article may belong to more than one area of research, which is/are chosen depending on the focus of the study. This indicator aims to direct future studies by highlighting hot areas of research or potential areas.

2.2. Systematic Review

Additional to the bibliometric review, the systematic review of the literature aims to support the analysis of published studies qualitatively, seeking to find literature gaps in a detailed and specific way. In this study, the systematic review was supported by the PRISMA meta-analysis method, which provides transparency to the systematic review [25]. A table was compiled using the data collected from the documents selected to identify the focus of the most relevant studies on the topic and their contributions to the literature.

As stated earlier, the PRISMA method is a four-phase process, as represented in Figure 1. In the "Identification" phase, results are presented for the search carried out in the Scopus database using the string developed to find studies on the electric vehicle supply chain. For this study, 545 documents were found. In the "Screening" phase, some exclusion criteria were applied to select the documents to be analysed in this study. Only articles were considered as a document type. The language filter was used to select articles in English, as the most relevant research is published in that language. Only recent articles, articles from 2018 to 2022, were analysed to evaluate what was studied before and during the COVID-19 pandemic. In addition, only articles classified as open access were considered. After these filters were applied, 105 documents met the criteria. After selection, the title and abstract were read carefully in the "Eligibility" phase to verify if the researched topic was relevant. In this case, some documents found through the developed search string only mentioned the keyword "supply chain" in the abstract, keywords, or reference topics, but the real objective of the study was not related to discussion of supply chains. Some studies were excluded that dealt with the supply chain of fuel or energy to be used in electric vehicles, such as gasoline, hydrogen, and renewable sources of electricity. Other studies cited the keyword "supply chain" to investigate the use of electric vehicles in other supply chains, for instance in the food supply chain. However, the use of electric vehicles in supply chains is not the objective of the analysis proposed in this work, but the analysis of the supply chain of these vehicles. In addition, only articles with citations were considered. Thus, 48 articles met the eligibility criteria. Finally, in the "Included" phase, the number of documents included in the meta-analysis is presented. The following questions were designed to qualitatively analyse the selected studies, which are then related to the quantitative indicators used in the bibliometric analysis:

1. At what point in the supply chain was the study focused?
2. What type of analysis was used?
3. Which supply chain process was analysed?
4. Which component did the analysis focus on?

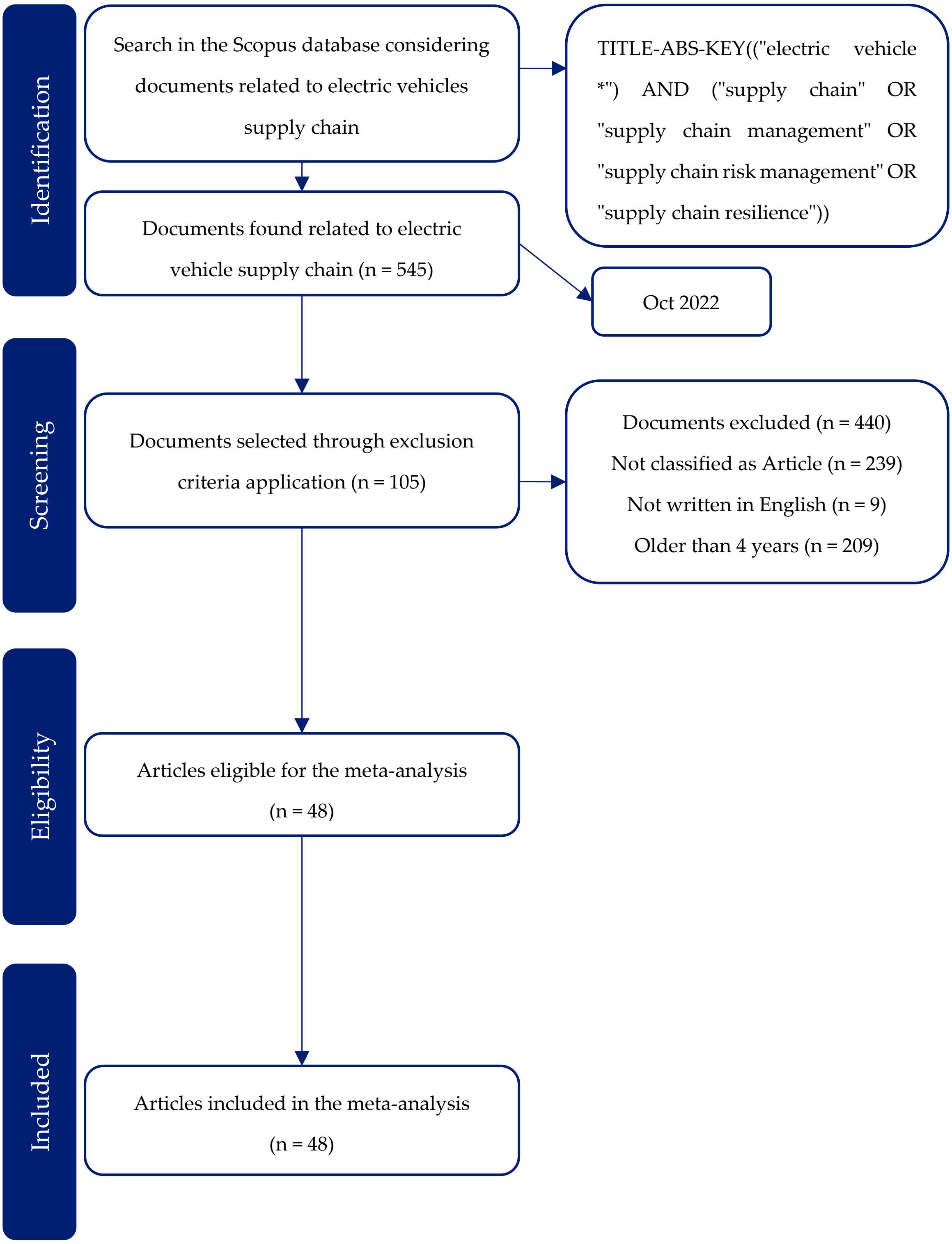


Figure 1. Detailed flowchart illustrating the PRISMA meta-analysis steps. The * was used to find derivations of the word "electric vehicle", such as singular and plural.

3. Results and Discussion

The presentation and discussion of the results are divided into two subtopics to cover the results of each type of review in more detail. First, the results of the bibliometric study are discussed to find critical points and gaps in the literature. Then, the discussion focuses on the systematic review, showing in detail the flowchart developed and the details of the articles selected. Sections 3.1–3.6 present the results found through bibliometric analysis, and Section 3.7 presents the PRISMA meta-analysis.

3.1. Partnerships between Countries

Figure 2 shows the relationships between countries, as indicated by collaborations observed in the literature. The country with the most significant international cooperation was China. In addition, China is the leading manufacturer of high-scale production among emerging economy countries, allowing it to achieve competitive market prices. Furthermore, to ensure competitiveness, China periodically seeks to reduce production costs through studies of the supply chain, applying strategies such as just-in-time solutions; therefore, these studies can help decision-makers to develop policies and cost-reduction strategies to be used in practice.

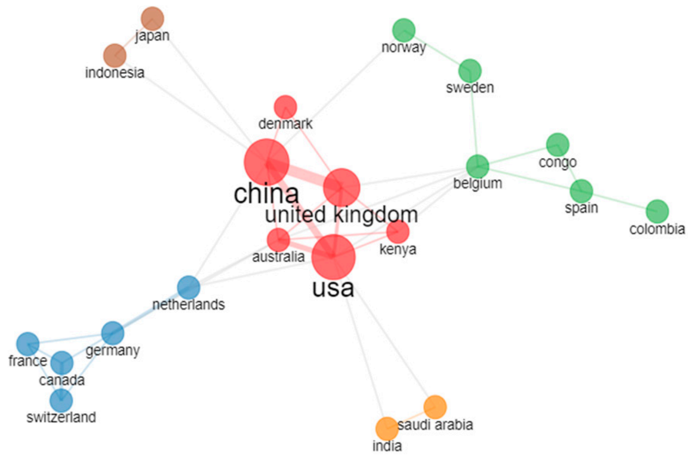


Figure 2. Partnerships between countries. (Elaborated through the Bibliometrix software).

Among the countries in collaboration with China, the United States appears as the second largest publisher with international cooperation, with 14 publications. The United Kingdom and Canada also published in partnership with China, totalling 12 and 4 documents, respectively, in addition to European Union countries. This clearly shows the cooperation between China and the first world countries, explained by the interest in inputs that are available on a large scale and at low cost from China, as these countries have high purchasing power.

Brazil did not publish any documents in international cooperation, reinforcing the need for partnerships in the field of the production chain linked to electric vehicles. Because it has the potential to generate renewable energy, such as solar and wind power, a mostly renewable electricity matrix [26], as well as mineral resources and the greatest biodiversity and forest territory on the planet, Brazil can contribute to supply cost reductions and minimize the environmental impacts caused by the use of electrical energy from the burning of fossil fuels. The Russian Federation published two articles that were not considered open access and one of them was not written in the English language; therefore, they were not cited in this work. The results reveal cooperation between the Democratic Republic of Congo and first-world countries, such as Belgium and Spain, with one document each. This is related to its potential in the cobalt supply, a critical component to producing electric vehicle batteries.

3.2. Co-Occurrence of Authors' Keywords

Keywords can be analysed according to their number of occurrences and co-occurrence with other keywords. The number of occurrences was analysed using the Bibliometrix software (Figure 3), in which it was possible to visualize the words with the highest and lowest occurrences, suggesting gaps and trends in the literature.

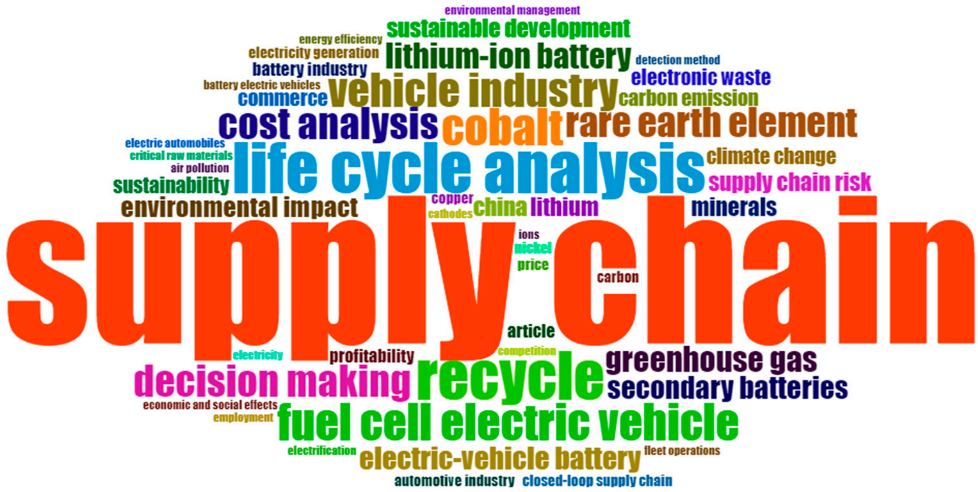


Figure 3. Co-occurrence of authors' keywords. (Produced using the Bibliometrix software).

It can be seen in Figure 3 that the keyword "life cycle analysis" received the most focus among studies on the electric vehicles supply chain, and this keyword was directly linked to other types of investigations, such as the study of impacts caused mainly by the consumption of electric energy and the production of batteries. The authors of [1] considered the synthetic fuel production chains, such as those for hydrogen and synthetic natural gas, and electricity, as well as domestic and imported generation, to analyse greenhouse gas emissions. According to their results, battery electric vehicles had lower emissions when assuming a scenario that considers additional energy demand options, such as seasonal storage. However, when role of electricity has to be reduced, the battery electric vehicle is only the best choice if the imported electricity is low carbon or the domestic electricity is generated through renewable energy such as photovoltaic expansion.

The economic viability of electric vehicle deployment should be widely discussed, as upgrading the electrical grid only to support electric mobility will result in negative macroeconomic impacts. According to [27], electricity grid upgrade costs will be passed on to electricity consumers, resulting in more expensive bills. Buyers with lower monthly incomes, who are a concern for decision-makers, or should be, will not suffer as much.

The frequency of the keyword "cost analysis" can be observed. This is because many studies analyse economic feasibility to complement the life cycle assessment through a cost analysis of the fuel used or battery components that might reduce the cost of the product. Nonetheless, the life cycle cost was not used as a keyword, so it does not appear in the authors' keywords. However, despite the small number of studies, the life cycle cost and the levelized fuel production cost were analysed.

In [28], the cost of owning and driving a fuel-cell electric vehicle powered by green hydrogen, that is, hydrogen produced through electrolysis and renewable energies, is analysed. Among the costs analysed was the levelized cost of hydrogen production and its supply chain. The total cost of ownership considered the following: the emissions related to the hydrogen production pathway; the vehicle powertrain, and the emissions related to its production; the taxes and subsidies provided for the purchase and usage of the vehicle; the pattern of using the vehicle, such as charging facilities and sharing of electric mode, as is the case of the plug-in electric vehicle; and, finally, the levelized energy cost per kilometer, fuel/energy cost, capital expenditure, and operational expenditure. However, owning and driving costs have been calculated less frequently. The most recent studies have focused on reducing costs related to fuel production and the components of electric vehicles. The authors of [29] carried out a sensitivity analysis to identify the key factors affecting hydrogen prices. Considering a projection after 2030, the authors concluded that hydrogen demand will increase significantly, and investments in infrastructure will be needed to satisfy it. Besides that, the feedstock price is one of the parameters that affect the hydrogen price.

The "lithium-ion battery" was the keyword used in several studies, especially in studies about chemical components, such as "cobalt" and "lithium". A life cycle analysis has been carried out to investigate cobalt production, considering the ore grade, the primary production, and the lithium-ion battery recycling [30]. The results showed that cobalt production from its ore must be minimized due to its high projected environmental impact up to 2050. One alternative to reduce the environmental impact of cobalt production is increasing cobalt recycling rates and efficiency, which can reduce the ore mining activities and its consequent impacts [30]. On the other hand, the scarcity and disruption of materials considered critical, such as lithium, cobalt and nickel in the supply chains, may hinder the large-scale production of lithium-ion batteries that are composed mainly of the aforementioned materials and make the 25% share in the electric vehicle market by 2050 unfeasible [31]. When the environment is discussed, considering the whole battery supply chain, the lithium-ion battery will only reduce climate change if suppliers use renewable sources for power generation [32]. However, a supply chain majority powered by renewable energies contributes to the increase in the human toxicity factor, land use, and water consumption [33]. Therefore, in the medium term, a balance of prices, environmental impacts, and human health must be considered. It is important to emphasize that the increase in battery demand will consequently increase the demand for mineral components. This can result in higher prices of cobalt than for nickel and higher nickel prices than for copper [2]. Governments must create subsidies to make the recycling sector more economically feasible. It is critical to know the remaining useful life of the batteries once it is a factor that directly affects the supply chain. This makes is possible to reduce the impact on the management on the demand side [34]. In addition, the search for decarbonization and emission mitigation leads to increased demand in the electricity sector and biofuel production, such as hydrogen [35].

As shown in the word cloud in Figure 3, the keyword "rare-earth elements" appears with high frequency. These elements have received much attention due to their recent exploration, and each rare-earth element has a specific end use [36]. Therefore, there is an urgent need for further production of these rare-earth elements as a by-product of other commodities, such as bauxite or phosphate, to minimize their scarcity, but technical and economic challenges still need to be overcome.

When analysing the recent studies, it was found that "electric vehicle battery" is a keyword that stands out in several of them. To explore the strengths and weaknesses of this supply chain, [37] carried out a SWOT analysis of the United Kingdom's electric vehicle battery industry. They suggested that the battery manufacturers should reduce the reliance on sourcing from a single country supplier, in this case, China, and fortify the interaction with other suppliers, such as India, Africa, and the United States, maintaining continuous innovation.

The keyword "supply chain risk" was one of the least used keywords. Recently, the pandemic caused by COVID-19 has impacted several sectors of the industry, with the application of protective measures to reduce transmission, such as lockdowns. It was not different in the electric vehicle sector, which faced interruptions in production and in sales, leading to innovation in online sale channels [38]. To reduce these impacts, [39] realized an investigation about the potential COVID-19 impacts on the electric vehicle supply chain on a global scale and suggested an integrated supply chain model. This model uses a supply chain risk management concept based on the possibility of disruptions occurring in the electric vehicle supply chain due to the coronavirus pandemic.

The COVID-19 pandemic also brought uncertainties in the magnetic elements supply chain, which are components of vehicle electronics equipment, such as neodymium-iron-boron (NdFeB) magnets. To reduce the scarcity of this material, [40] proposed a supply chain and logistics network design based on reverse resilience. The authors considered collection, disassembly and recycling centres. In addition, uncertainty criteria were used to analyse the lithium supply chain. According to [41], the lithium supply chain is highly complex due to the interconnections and interdependencies between its elements. This means that a vehicle needs a lithium battery, but a lithium battery requires lithium carbonate and lithium hydroxide for its production. One of the solutions found by the authors was to produce lithium hydroxide from lithium carbonate, thus reducing the demand for lithium.

Supply chain risks were also applied considering other impacting factors, such as corruption and political instability, in the raw material mining sector for lithium-ion batteries, specifically cobalt, rare-earth elements, and lithium [42]. In addition, these materials can be replaced with similar materials without changing the product's design. However, specific rare-earth elements still lack investigations since their alternatives are poorly known or less effective [42].

Another point that deserves attention is the diversity of raw materials, which can contribute to the risk of ruptures in the supply chain. The authors of [43] analysed exactly this point by presenting methods developed to assess supply chain risk in relation to geopolitical factors, the potential for economic scarcity and resource efficiency. According to the results, the methods presented may only be valuable for preliminary assessments of the outside-in impacts, which are the impacts of raw materials on production processes, and the inside-out impacts, which encompass the effects of production processes in the environment. Furthermore, the authors emphasize that critical raw materials should not be neglected, even if they are only used in small quantities.

In addition to analysing the supply chain for the delivery of electric vehicles as a product of the production process, the possibility of supplying batteries for energy storage systems or electronic devices was also considered, for example, when there is no demand for electric vehicles [39]. This makes it possible to reduce the impact on the upstream side of the supply chain. The concepts of upstream and downstream have been analysed in the context of competitiveness. According to the analysis performed by [44], an upstream electric vehicle manufacturer that produces batteries may sell them to a downstream electric vehicle manufacturer that does not produce batteries, depending on the external battery manufacturer. Only if the acquisition cost is reasonable, the downstream manufacturer prefers to order the battery from the upstream manufacturer. To maximize social welfare, the authors also concluded that the upstream manufacturer does not supply batteries to the downstream manufacturer if the acquisition cost from the external supplier is low. On the other hand, the upstream manufacturer will provide batteries to the downstream competitor if the battery acquisition cost is low.

It was observed that the keyword "recycle" was present in many studies. However, to recycle any products, there need to be incentives. The subsidies for recycling batteries, for instance, can be provided to the manufacturer or the consumer, but the subsidies provided to the manufacturing sector provide more significant profit and social welfare than the incentives provided to consumers [45]. This can be explained by the costs involved in managing the battery at the end of its life and forwarding it to the recycling sector. The authors of [46] presented a techno-economic model to compare recycling locations and processes for recycling cost optimization, considering an international battery recycling economy. The authors showed that recycling can be economically feasible and can contribute to mitigating the emissions caused by mining processes of the components needed, for example, and can secure the materials supply chain.

Another possibility to recycle batteries is allocating them to another purpose, such as the distributed energy system sector. The authors of [47] proposed an optimisation to a supply chain using electric vehicle batteries that have reached the end of their lives. This use allows optimal supply chain profits and fairness of profit allocation. Considering profit, strategic alliance between suppliers and manufacturers might effectively optimize the returns in the whole supply chain, and these alliances can be coordinated through different mechanisms, including Nash-bargaining, which means that the manufacturer holds bargaining power α, and the suppliers hold $1-\alpha$ [48].

Although recycling and reusing electric vehicle batteries can help reduce raw material consumption and negative environmental impacts, these activities may not bring financial benefits [49]. This analysis presented the concept of a "closed-loop supply chain", a set of activities responsible for producing, distributing, and delivering the product to customers and collecting it for recovery processes at the end of its life. In this analysis [49], important points about closed-loop supply chains and recycling technologies were discussed. Although more returns reduce raw material demands, the authors concluded that the closed-loop battery supply chain showed lower profit when more batteries were returned, suggesting government's participation with incentives may increase recycling-related profit. Furthermore, the higher the recycling rate and lower the cost, the higher the profit, indicating that the efficiency of the process and the technology used to recycle need to be optimised [49].

Profit was analysed separately in a closed-loop supply chain consisting of a manufacturer, which produces new batteries available to the consumer, and a remanufacturer, which collects the end-used battery and recycles it depending on its return quality [50]. This analysis showed that the price of high-quality returned batteries influences the remanufacturing decision more than that of low-quality batteries, and incentives are necessary to promote remanufacturing, as this sector benefits the environment. According to the authors, the manufacturing sector profits more than the remanufacturing sector, making it challenging to propose recycling batteries and their components.

Recycling can be directly linked to various strategies, including the circular economy [51–53]. The circular economy promotes the possibility of using materials at their end of life, recovering components that would be discarded to use in new products after dismantling and selecting steps, and it is a broader topic than the closed-loop supply chain. In addition, the circular economy is essential to fortifying supply chain resilience and sustainability because it helps to minimize the mineral components demand, such as cobalt. Although cobalt is not widely used, its independence can overwhelm the demand for other materials, such as nickel [52]. Recycling 4.0 has been used to optimise the circular economy strategies, integrating recycling with Industry 4.0. Thus, the marketplaces operate as a central contact point in which suppliers and customers are linked to combine an optimal recycling system with intelligent robotic systems and automation strategies [51].

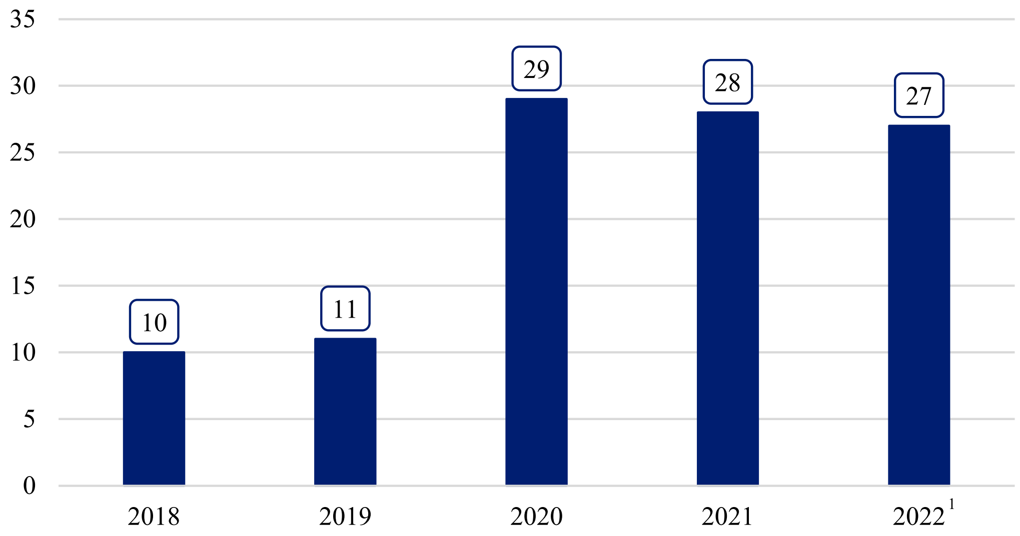
Sustainable supply chain management is a branch of supply chain management that focuses on measures to mitigate sustainability-related risks. Nevertheless, looking at Figure 3, the sustainable supply chain is relatively less focused than the supply chain. Furthermore, supply chain transparency for sustainability has not been studied as much. The transparency between internal processes is an important point because it contributes to improving collaboration throughout the supply chain by optimising the traceability of raw materials, components, and products [54].

Synthetic gas supply chains, such as that for natural hydrogen gas, were analysed in some studies. The authors in [1] investigated the greenhouse gas emissions of a fuel cell electric vehicle fuelled with hydrogen and an electric vehicle fuelled with synthetic natural gas. Both are produced with carbon dioxide via direct air capture. The results showed that using these synthetic gases is even more efficient than a battery electric vehicle when considering a scenario with curtailment of electricity demand, which can be explained by the longer storability of these fuels.

Plug-in electric vehicles were less analysed in relation to both the supply chain for their production and their use in the logistics sector. The use of electric vehicles in the logistics sector is a challenge due to the size of the trunk, which must be large enough to transport objects for delivery [55]. In addition, charging time must be analysed to balance distribution costs with time efficiency for longer delivery distances. However, if the distance is shorter, time does not interfere since electric vehicles have enough autonomy to go back to the store and recharge the battery. The only concern is the right choice of the vehicle model for delivery [55]. Electric mobility can also be included in a small supply chain. Farmers can use an electric vehicle to carry out logistics for local food markets, and the stronger this partnership, the greater the intention to use the electric vehicle for this purpose due to the short distance and the number of products to be delivered [56].

3.3. Publications Per Year

In the analysed period, 2020 and 2021 stood out the most in terms of publications (Figure 4), possibly due to the challenges caused by the spread of COVID-19, which brought risks to the production chain. During the pandemic, there was mandatory minimum distancing in the workplace, and stores closed or operated with reduced hours due to the lockdown, consequently reducing the opportunity to purchase products. In addition, during the pandemic, consumers opted to buy survival products, such as food, medicine, masks, face shields and gloves, leaving aside the purchase of objects that had no immediate use, such as clothes, alcoholic beverages, shoes and especially vehicles. On the other hand, the purchase of electronics increased, as there was, and still is, the home-office modality. In this way, both demand and supply were met, bringing the need for studies and investigations aimed at reducing supply costs that result in reductions in the final price. It is essential to highlight that the search in the database considered only the first third of 2022 and may present studies still in the publication phase.



[1] In 2022, only documents published up to the search date of this work (May, 2022) were considered.

Figure 4. Number of publications for each year. (Chart produced in Microsoft Excel).

3.4. Publications by Country

The countries that produced most articles on the topic analysed were China, the United States of America, and the United Kingdom, which published 27, 27 and 23 articles, respectively. Publications extended to most of the countries in the European Union and Canada, corroborating the analysis of item (a) of this section.

It is important to observe in Figure 5 the divergent situation among the countries that make up the BRICS. Unlike China, India, and South Africa, no articles on this topic were published by Russia and Brazil between 2018 and 2022, considering the filters applied. A possible explanation for China and India's roles can be the size of the national population and the need to seek alternatives to reduce the emissions caused, mainly in the transport sector. The situation in South Africa is related to the wealth of mineral reserves, including copper, which is one of the elements used in lithium-ion batteries [57].

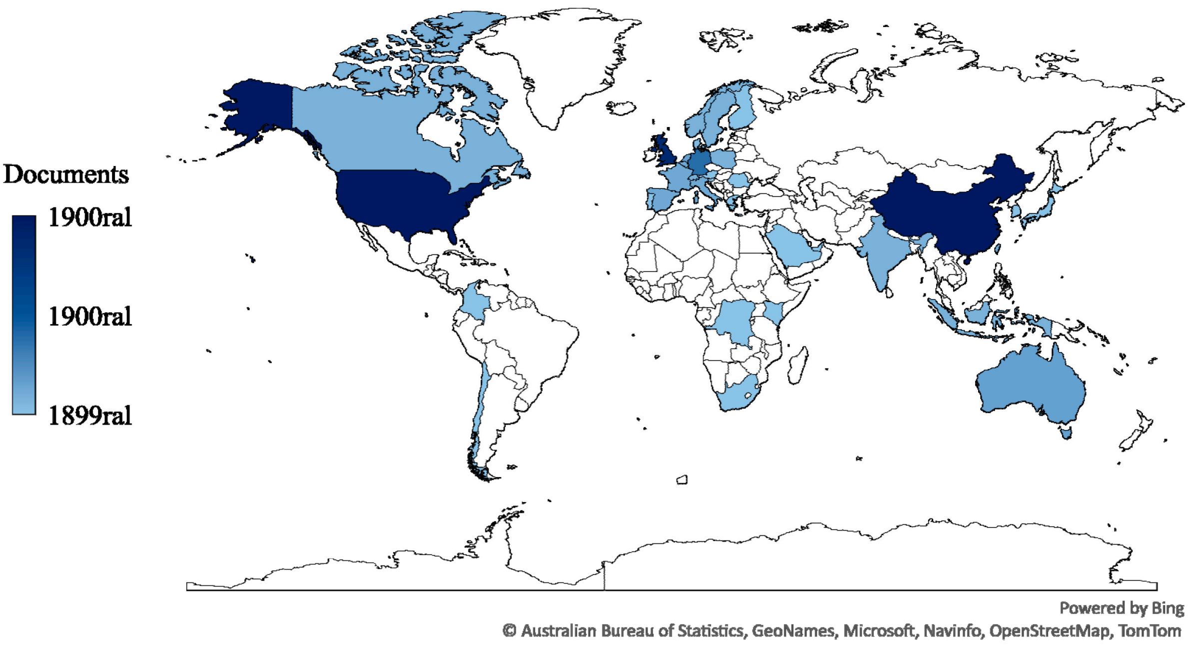


Figure 5. Number of publications by country. (Chart produced in Microsoft Excel).

Brazil did not contribute any publications on the topic. First, the articles published in Brazil were classified as reviews [58,59], and this work focused only on documents classified as articles. Another possible explanation is that the electric vehicles used in the country are, in general, imported. Recently, Toyota started manufacturing various types of electric vehicles on Brazilian soil. However, these represent a relatively small portion of the Brazilian fleet of light vehicles, and therefore, the topic has not yet caught the attention of researchers focused on the supply chain. In the case of Russia, two articles were found. However, both were not classified as open access [60,61]. Another point was that one of the articles found was written in Russian. Countries located on the European continent published 60 articles. This could be attributed to Europe being the largest electric light vehicle market, with consistent growth. In 2021, European hybrid electric vehicles increased by 68.21% due to their emissions regulation and incentive programs [62].

3.5. Impact Factor by Journals

To analyse the impact factor of journals, the h index was considered. The h index is based on the most cited articles in a magazine or newspaper, where the number of articles with citations is greater than or equal to an "h" number [63]. For example, a journal with an h-index of 3 has three cited articles with three or more citations. In Figure 6, it is possible to observe that the journals Energies, Sustainability, Applied Energy, and Energy Policy, which included eight, seven, three, and three published documents, respectively, had an h index equal to three, considering the articles published between 2018 and 2022. Sustainability is a journal linked to the Multidisciplinary Digital Publishing Institute (MDPI), with an impact factor of 3251, which covers topics related to environmental, cultural, economic, and social sustainability, and encompasses studies on sustainability and sustainable development. Energies is also an open-access MDPI journal, with an impact factor of 3004, which focuses on the publication of studies related to scientific research, technological development, and engineering and the areas of policy and management. These two journals had the highest number of publications between 2018 and 2022, with eight and seven documents, respectively. Energy Policy is a journal provided by Elsevier, with an impact factor of 6142. Its scope covers the political implications of energy supply and use by analysing economic, social, environmental, and planning aspects. Finally, Applied Energy, annexed to Elsevier, has the highest impact factor among those mentioned above, with 9746. This journal focuses on publications related to energy conversion, energy resources and processes, mitigation of environmental pollutants, and sustainable energy systems. Figure 7 shows the number of publications of the most relevant journals, including the aforementioned ones. Thus, these journals can be seen as good options to submit articles on the electric vehicle supply chain.

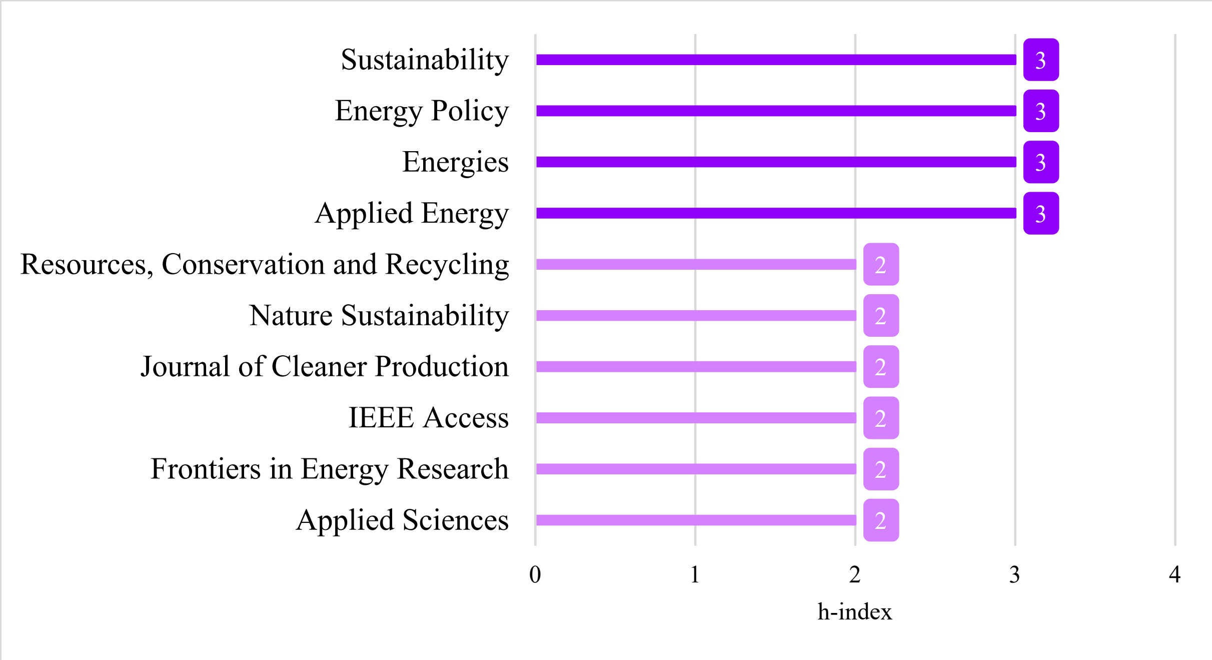


Figure 6. liImpact factor of journals. (Chart produced in Microsoft Excel).

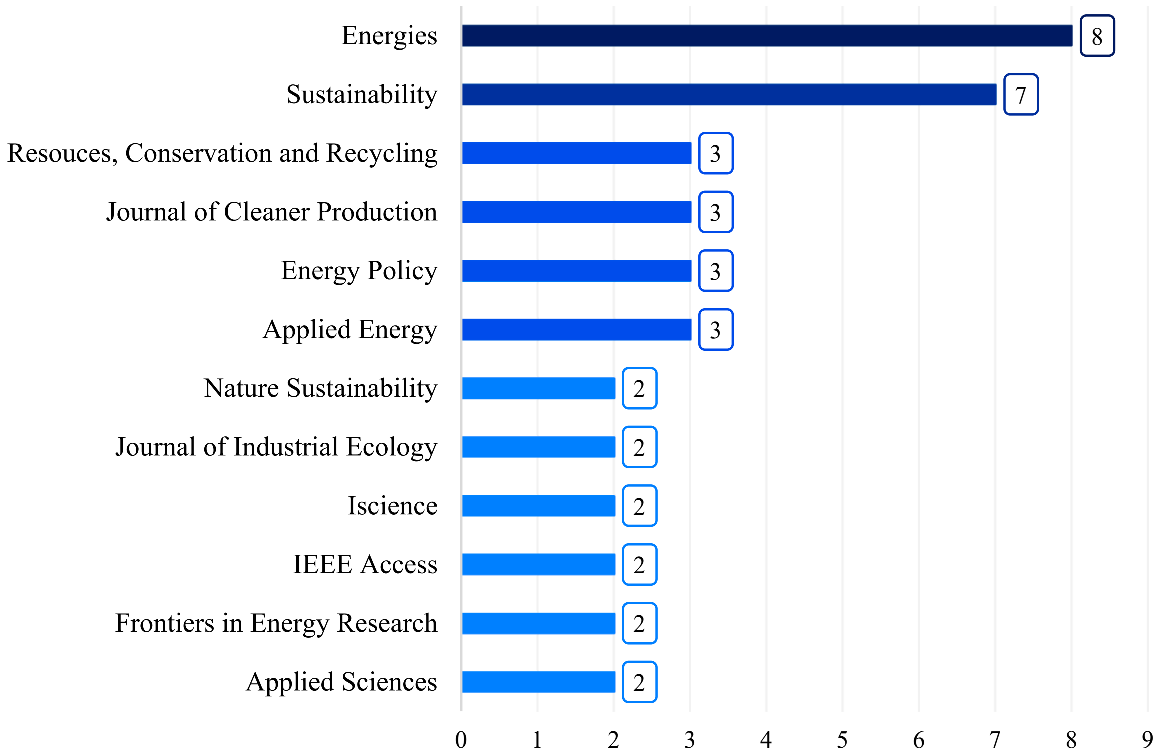


Figure 7. Number of publications of the most relevant journals. (Chart produced in Microsoft Excel).

3.6. *Areas of Research*

The most relevant areas of research chosen for the articles published on electric vehicle supply chains are shown in Figure 8. As can be seen, the areas related to critical materials used in the batteries of electric vehicles are the most relevant, disregarding those areas that were used as keywords in the search chain (electric vehicle and supply chain management). This can easily be explained by the fact that batteries are the most concerning component in discussions of electric vehicle manufacturing, as they depend on materials considered critical in the automotive and electronics industry, such as lithium, cobalt, and silicon. The latter is one of the main chemical components for semiconductor manufacturing, used in the manufacture of chips for much electronic equipment, including that used in electric vehicles. This concern is so great that among the areas of research is one of the techniques for recovering discarded products for the possible recovery of these critical chemical components (closed-loop supply chain) and the application and analysis of these studies in real cases.

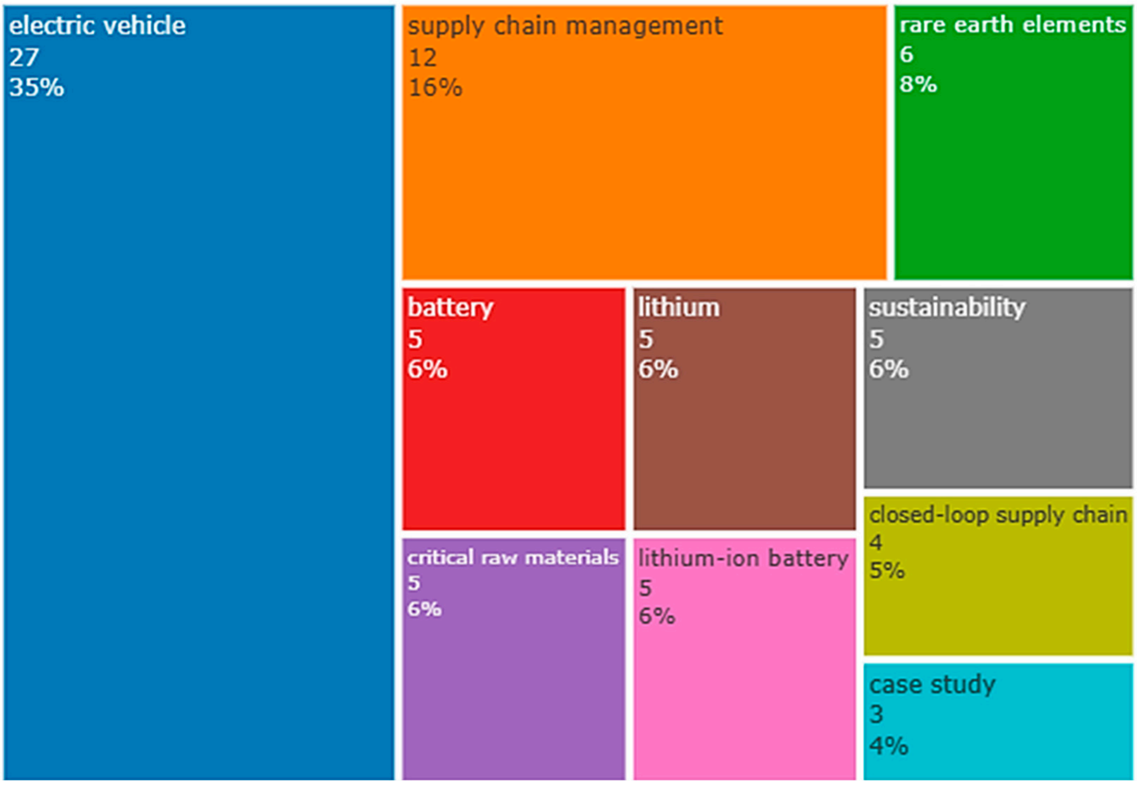


Figure 8. Most relevant areas of research. (Visual produced by the Bibliometrix software).

3.7. *PRISMA Meta-Analysis*

For the PRISMA meta-analysis, the table shown in Appendix A explores in detail articles with citations equal to or greater than 1. Many articles studied general terms and were classified as "unspecified". Finally, each question was answered separately to complete the analysis, and related to the quantitative indicators used in the bibliometric review.

1. *At what point in the supply chain was the study focused?* In Appendix A, it is possible to observe that raw material supply chain management was extensively studied. However, the focus of the studies was on recycling components for reuse in remanufacturing processes. This view was supported by the authors' keywords indicator used in the bibliometric analysis. Recycling is seen as an alternative to reduce metal and mineral extraction practices and reduce negative environmental impacts related to improper disposal of chemical components. Moreover, it appeared as the focus even before the COVID-19 pandemic. The approaches to reuse and allocation of

electric vehicle batteries, which can be understood as the use of a component for another purpose, have been poorly analysed and further studies should focus on this point. This can be easily found in studies that investigate electric vehicle batteries in the energy storage system.

2. *What type of analysis was used?* Environmental impact assessments were presented in several studies. Highlighting the environmental impacts caused by the production of chemical components and their inappropriate disposal allows decision-makers and government agencies, together with society, to create awareness programs and encourage recycling. Not only must the environmental analysis be conducted, but also the costs and profits analysis in the production chain, because when the cost of recycling exceeds the profit of the manufacturer, there is no interest in mitigating pollution. This emphasizes the need for contributions from government agencies to create subsidies in this sector. The importance of cost analysis is illustrated by the number of studies found on this topic. In addition, life cycle assessment was the third most studied term. However, the analysis and development of policies and subsidies have been little studied and require further investigations so that electric vehicles and their supply chains are viable and arouse consumers' interest in purchasing electric vehicles. Regarding the bibliometric analysis, this question can be easily answered by the authors' keywords and partnership between countries indicators, which led to similar conclusions.
3. *Which supply chain process was analysed?* The keyword "supply chain risk management" does not appear among the keywords indexed in the articles found. However, this term was the most recurrent topic when assessing the risks related to the raw material of chemical components of electric vehicle batteries. Additionally, several studies applied the concept of a closed-loop supply chain, which considers the production chain and the collection of the product at the end of its useful life. Although this concept was scarcely discussed in the bibliometric review of this work, through the authors' keywords indicator, its frequency among the selected articles in the systematic analysis reinforces the importance of applying the closed-loop supply chain concept in different areas. This could be because the keyword "closed-loop supply chain" was not frequently included in the keyword section. The partnership between countries is another bibliometric indicator that can answer this question since cooperation in studies arose from the need to bring together pioneering countries in extracting critical materials to mitigate demand and supply risks. On the other hand, the application of methods that enable transparency between supply chain processes, and their sustainability, is still poorly studied, which suggests a possible direction for further studies.
4. *Which component did the analysis focus on?* Electric vehicle batteries were the focus of the supply chain analysis, and cobalt and lithium were the most studied elements. Considering the studies analysed in the bibliometric review and the authors' keywords indicator, the demand for these elements tends to increase proportionally with the number of electric vehicles, since they are important constituents of the lithium-ion battery. In this way, the researchers sought to investigate alternative ways of meeting the demand for cobalt and lithium, mainly through recycling. Other important chemical components such as nickel and other critical raw materials (i.e., aluminium, copper, and manganese), and rare-earth elements were also analysed. Only one selected article analysed a specific point in the electric vehicle supply chain, which was the use of steel for chassis manufacturing. The recycling of electric and electronic equipment was rarely analysed among the selected articles. Therefore, these are points that further studies can focus on.

4. Conclusions

This work analysed the state-of-art of the electric vehicle supply chain through bibliometric and systematic reviews, using quantitative and qualitative analysis, to find critical points that may cause risks to the supply chain and that should be focused on in further studies. In addition, the electric vehicle supply chain was analysed considering the pre- and post-scenarios of the COVID-19 pandemic. Bibliometrix software was used to support the bibliometric analysis and the PRISMA method was applied in the systematic review. We provide important insights highlighting hot spots in the literature and areas that need attention to address gaps found in the literature. The authors' keywords were analysed throughout the study, which can be considered as a limitation of this work because some authors do not index their keywords in the database, and this can be seen especially in the systematic review since most of the selected articles do not include keywords, making the authors' keywords analysis incomplete. Although the study is based on a relevant database, the choice of only one database can also be seen as a limitation of the study, since combining results from different sources can reasonably influence the results found.

Both reviews carried out by different methods, qualitative and quantitative, brought similar conclusions, among which the main ones are: (1) alternatives to strengthen material recycling actions should be widely and more frequently discussed, to transform theoretical actions into practices that are attractive to the consumer and the manufacturer; (2) transparency in the supply chain can be considered as a direction for further studies that seek alternatives to improve communication between processes and reduce risks linked to uncertainties in demand and supply; and (3) incentive policies must be created to benefit manufacturers of electric vehicles and their parts so that their closed-loop supply chains are economically advantageous and do not overload the value of the product at the end of the chain. It is expected that the results presented here can assist researchers in conducting new studies and governmental bodies in decision making relevant to this area.

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Appendix A

Table A1. PRISMA meta-analysis of documents found about the electric vehicles supply chain.

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
The Rare Earth Elements: Demand, Global Resources, and Challenges for Resourcing Future Generations [26]	Rare earth elements; Resources; Supply chain; Minerals processing	Raw material supply	Not specified.	Supply chain risk management.	Rare earth elements
Sustainability of artisanal mining of cobalt in DR Congo [27]	-	Raw material supply	Environmental assessment; Exposure assessment.	Supply chain risk management; Sustainable supply chain management.	Cobalt
Sustainable minerals and metals for a low-carbon future [28]	-	Recycling	Environmental assessment; Policy recommendations	Closed-loop supply chain.	Exposed 35 critical materials, including: Cobalt, Graphite, Lithium, Manganese, and Rare earth elements
The case for recycling: Overview and challenges in the material supply chain for automotive li-ion batteries [29]	Cathode; Electric vehicles; End-of-lifeLi-ion batteries; Recycling	Recycling	Value of final product	Closed-loop supply chain.	Cobalt; Nickel; Manganese; Aluminium; Lithium; Graphite
Future material demand for automotive lithium-based batteries [30]	-	Recycling	Sensitivity analysis	Closed-loop supply chain.	Cobalt; Nickel; Manganese; Lithium
Circular economy strategies for electric vehicle batteries reduce reliance on raw materials [31]	-	Raw material supply; Recycling	Material flow analysis	Closed-loop supply chain.	Cobalt
Modelling reverse supply chain through system dynamics for realizing the transition towards the circular economy: A case study on electric vehicle batteries [32]	Circular economy; Reverse logistics; Remanufacturing; System dynamics (SD); Electric vehicle battery (EVB); Repurposing	Remanufacturing; Repurposing	System dynamics; Cost analysis	Reverse supply chain	Battery

Table A2. PRISMA meta-analysis of documents found related to electric vehicles supply chains. (continuation).

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Developing pricing strategy to optimise total profits in an electric vehicle battery closed loop supply chain [33]	Closed-loop supply chain; Electric vehicle battery; Recycle; Reuse; Profit	Manufacturing; Remanufacturing	Total profit analysis	Closed-loop supply chain.	Battery
Critical raw materials and transportation sector electrification: A detailed bottom-up analysis in world transport [36]	World transportation; Electrification; Critical raw materials; Lithium; Bottom-up modelling	Raw material supply	Times integrated assessment model	Not specified.	Lithium
Lithium Iron Aluminium Nickelate, LiNixFeyAlzO2—New Sustainable Cathodes for Next-Generation Cobalt-Free Li-Ion Batteries [34]	Cobalt-free cathodes; Iron redox; Layered cathodes; Lithium-ion batteries; Nickel-rich materials	Raw material supply	Neutron diffraction analysis; Microstructural analysis; Compositional analysis	Not specified.	Battery
The EV revolution: The road ahead for critical raw materials demand [35]	Decarbonisation; Electric vehicles; Metal; Mined commodities	Raw material supply; Recycling	Cost, Macro, Iinfrastructure, Technology (CoMIT) model	Supply chain risk management	Lithium, Cobalt
Optimising quantity of manufacturing and remanufacturing in an electric vehicle battery closed-loop supply chain [37]	Closed-loop supply chain; Recycle; Profit; Reuse; Electric vehicle battery; Purchasing price	Manufacturing; Remanufacturing	Nash equilibirum; Profit analysis; Purshasing price analysis	Closed-loop supply chain.	Battery
Raw material criticality assessment as a complement to environmental life cycle assessment: Examining methods for product-level supply risk [38]	Critical raw material; Industrial ecology; Life cycle assessment; Life cycle sustainability assessment; Raw material criticality assessment; Supply risk	Raw material supply	Life cycle assessment; Life cycle sustainability assessment;Raw material criticality assessment	Supply chain risk management	Critical raw materials

Table A3. PRISMA meta-analysis of documents found related to electric vehicles supply chains. (continuation).

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Globally regional life cycle analysis of automotive lithium-ion nickel manganese cobalt batteries [39]	Lithium-ion battery; Life cycle assessment; Automotive; Supply chain	Raw material supply	Life cycle analysis	Supply chain risk management	Lithium; Cobalt; Nickel
Impacts of COVID-19 on the electric vehicle industry: Evidence from China [40]	COVID-19 impacts; Electric vehicle; Market analysis; Supply chain; Policy trend; Future outlook	Raw material supply; Manufacturer; Distributors; Consumers	Not specified.	Supply chain risk management	Not specified.
LiNixFeyAlzO2, a new cobalt-free layered cathode material for advanced Li-ion batteries [41]	Li-ion batteries; Cobalt-free; Layered cathodes; NFA; Electrochemistry; Electric vehicles	Raw material supply	Complex non-linear least-squares regression analysis.	Not specified.	Cobalt-free NFA class cathodes
Financial viability of electric vehicle lithium-ion battery recycling [42]	-	Recycling	Cost analysis; Profit analysis	Supply chain risk management	Battery
Electric vehicle battery secondary use under government subsidy: A closed-loop supply chain perspective [43]	Battery secondary use; Recycle and remanufacturing; Incentive policy design	Reuse; Recycling; Remanufacturing	Political analysis	Closed-loop supply chain	Battery
Electric vehicle battery capacity allocation and recycling with downstream competition [44]	Supply chain management; Electric vehicle; Channel choice; Capacity allocation; Battery recycling	Recycling; Allocation	Equilibrium analysis; Profit analysis	Not specified.	
Li-ion batteries: A review of a key technology for transport decarbonization [45]	Lithium batteries; Electric vehicles; Sustainability; Emissions; Environment	Raw material supply	Environmental assessment and impacts; Cost analysis	Supply chain risk management	Lithium; Cobalt; Nickel; Graphite; Rare-earth elements

Table A4. PRISMA meta-analysis of documents found related to electric vehicles supply chains. (continuation).

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Managing resource dependencies in electric vehicle supply chains: a multi-tier case study [46]	Electric vehicle; Resource dependence theory; Supply chain management; Production ramp-up; Case study	Supply	Process-orientated honolic model; Cost analysis	Supply chain risk management	Not specified.

Table A4. *Cont.*

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Energy, greenhouse gas, and water life cycle analysis of lithium carbonate and lithium hydroxide monohydrate from brine and ore resources and their use in lithium ion battery cathodes and lithium ion batteries [47]	Lithium; Life cycle analysis; Battery electric vehicle; Brine-vs. ore-based lithium; Salar de Atacama	Raw material supply	Life cycle analysis	Supply chain risk management	Lithium
Global Electrification of Vehicles and Intertwined Material Supply Chains of Cobalt, Copper and Nickel [2]	-	Raw material supply	Sensitivity analysis	Supply chain risk management	Cobalt; Copper; Nickel
Mineral processing simulation based-environmental life cycle assessment for rare earth project development: A case study on the Songwe Hill project [48]	Rare earth elements; Mineral processing simulation; Life cycle assessment (LCA); Process simulation; Energy selection	Raw material supply	Life cycle analysis; Environmental analysis	Not specified.	Rare earth elements
Transparency for multi-tier sustainable supply chain management: A case study of a multi-tier transparency approach for SSCM in the automotive industry [49]	Sustainable supply chain management (SSCM); Supply chain transparency; Multi-tier SSCM; Sustainability; Automotive industry; Case study research	Raw material supply	Within-case analysis	Sustainable supply chain management; Supply chain transparency	Cobalt

Table A5. PRISMA meta-analysis of documents found related to electric vehicles supply chains. (continuation).

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Emerging supply chain of utilising electrical vehicle retired batteries in distributed energy systems [50]	Electrical vehicle (EV); Retired battery; Distributed energy system (DES); Supply chain; Game theory; Optimisation model	Recycling	Profit-allocation model; Distributed energy system design optimisation model	Not specified.	Battery

Table A5. *Cont.*

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Enabling the Electric Future of Mobility: Robotic Automation for Electric Vehicle Battery Assembly [51]	Automation; Digital simulation; Digital twin; Electric vehicles; EV batteries; Industrial robots; Lithium-ion batteries; Robots; Robotic assembly	Manufacturing	Not specified.	Supply chain risk management	Battery
Recycling 4.0-digitalization as a key for the advanced circular economy [52]	Industry 4.0; Intelligent systems; Internet of Things (IoT); Recycling; Information marketplace; Sustainability	Recycling	Holistic approach	Circular economy	Battery
An Obsolescing Bargain in a Rentier State: Multinationals, artisanal miners, and cobalt in the Democratic Republic of Congo [53]	DRC; Rentier state; Obsolescing bargain; Cobalt; ASM; Electric vehicle; Responsible sourcing; Political economy	Raw material supply	Political-economy analysis	Supply chain risk management	Cobalt
Closed-loop supply chain planning model of rare metals [54]	Rare metal; Closed-loop supply chain; Supply chain planning model; Sustainable supply chain; Extended producer responsibility; Rare metal stockpile	Raw material supply; Recycling	Supply chain planning model; Sensitivity analysis	Closed-loop supply chain.	Rare earth elements

Table A6. PRISMA meta-analysis of documents found related to electric vehicles supply chains. (continuation).

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Implementation of Hybrid Blockchain in a Pre-Owned Electric Vehicle Supply Chain [55]	Automobile sector; Blockchain; Distributed ledger; Cloud; Mobile application; Ethereum sandbox; Meta mask; Transaction; Vehicle; Transparency; Truffle; QR code	Manufacturing	Not specified.	Supply chain transparency; Blockchain	Not specified.
Challenges to the European automotive industry in securing critical raw materials for electric mobility: The case of rare earths [56]	Rare earths; Critical metals; Criticality; Mitigation strategies; Electric vehicles; Automotive industry	Raw material supply	Not specified.	Supply chain risk management	Rare earth elements

Table A6. *Cont.*

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Sources of uncertainty in the closed-loop supply chain of lithium-ion batteries for electric vehicles [57]	Supply chain uncertainty; Closed-loop supply chain; Electric vehicle; Lithium-ion battery; Automotive industry	Recycling	Uncertainty analysis	Closed-loop supply chain	Battery
Prospective environmental impacts of passenger cars under different energy and steel production scenarios [58]	Life cycle assessment; Battery electric vehicles; Plug-in electric vehicles; Fossil-free steel; Prospective LCA	Supply	Life cycle assessment; Environmental impacts	Not specified.	Iron; Steel
Assessment of the supply chain under uncertainty: The case of Lithium [59]	Lithium; Batteries; Electric vehicles; Supply chain; Demand; Uncertainty	Raw material supply	Uncertainty analysis; Material flow analysis	Not specified.	Lithium
Agent-based modelling of supply disruptions in the global rare earths market [60]	Rare earth; Critical material; Agent-based model; Supply disruption; Supply chain	Raw material supply	Agent-based model	Supply chain risk management	Rare earth elements

Table A7. PRISMA meta-analysis of documents found related to electric vehicles supply chains. (continuation).

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
From "obligated embeddedness" to "obligated Chineseness"? Bargaining processes and evolution of international automotive firms in China's New Energy Vehicle sector [61]	-	Supply; Manufacturing	Not specified.	Supply chain risk management	Battery
Policy competition in clean technology: Scaling up or innovating up? [62]	Industrial policy; Environmental policy; Competitiveness; Solar; Electric vehicles	Manufacturing	Environmental policy	Not specified.	Not specified.
Resilient NdFeB magnet recycling under the impacts of COVID-19 pandemic: Stochastic programming and Benders decomposition [64]	Rare earth magnet; Supply chain optimization; Reverse logistics; Stochastic programming; Bender's decomposition; COVID-19 pandemic	Recycling	Chance-constrained two-stage stochastic programming model	Reverse logistics	Neodymium-iron-boron magnets

Table A7. *Cont.*

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Circularity for electric and electronic equipment (Eee), the edge and distributed ledger (edge&dl) model [65]	Circularity; Circular supply chains; Distributed ledger; Edger computing; E-waste; WEEE; Case study	Recycling	Material flow analysis	Reverse supply chain	Electric and electronic equipment
A swot analysis of the uk ev battery supply chain [66]	Electric vehicle; Battery; Supply chain management; SWOT analysis	Supply; Manufacturing	SWOT analysis	Supply chain risk management	Battery
Lithium in the green energy transition: The quest for both sustainability and security [67]	Lithium; Energy security; Sustainability; EVs; LIB; Battery; Lithium-ion	Raw material supply; Recycling	Not specified.	Not specified.	Lithium

Table A8. PRISMA meta-analysis of documents found related to electric vehicles supply chains. (continuation).

Title [Reference]	Keywords	(I) at What Point in the Supply Chain Was the Study Focused?	(II) What Type of Analysis/Model Was Used?	(III) Which Supply Chain Process Was Analysed?	(IV) Which Component Did the Analysis Focus on?
Promoting electric vehicle cell innovation diffusion considering patent licensing strategy: A combination of evolutionary game and optimization algorithm approach [68]	Innovation diffusion; Patent; System dynamics; Evolutionary game; Optimization algorithm	Manufacturing	Multistage and multichannel diffusion model	Supply chain risk management	Electric vehicle cell
Modelling potential impact of COVID-19 pandemic on global electric vehicle supply chain [69]	-	Not specified.	Economic analysis	Supply chain risk management	Not specified.
The impacts of subsidy policies and channel encroachment on the power battery recycling of new energy vehicles [70]	Closed-loop supply chain; Government subsidy; Recycling channel encroachment; Retired power battery; New energy vehicles	Recycling; Reusing	Economic analysis; Environmental analysis	Closed-loop supply chain	Battery
Policy competition in clean technology: Scaling up or innovating up? [62]	Industrial policy; Environmental policy; Competitiveness; Solar; Electric vehicles	Manufacturing	Environmental policy	Not specified.	Not specified.
Driving mechanism of power battery recycling systems in companies [71]	Battery recycling; Technological innovation; Alternatives; System dynamics	Recycling	System dynamics; Cost analysis	Closed-loop supply chain.	Battery

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