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Review Paper

An Investigation of Pull and Push Factors in the Commercialization Policy of Electric Motorcycles in Indonesia

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Abstract

The ongoing energy crisis underscores the pressing need for more efficient energy utilization, particularly in the transportation sector. In this regard, the shift from conventional fossil fuels to electric vehicles (EVs) is essential for achieving both environmental sustainability and energy efficiency. Several developing countries, including Indonesia, have introduced regulations to promote EV adoption. However, electric motorcycle sales remain stagnant due to persistently low adoption rates. The primary challenge lies in the limited success of commercialization efforts, which continues to hinder broader market penetration in Indonesia. This study aims to identify research opportunities that can support the commercialization of EVs in Indonesia and to explore the push and pull factors influencing this process. An exploratory approach is employed, incorporating bibliometric analysis using R 4.3.1, a scoping literature review, and in-depth interviews with EV experts. The bibliometric analysis highlights the considerable development potential of electric motorcycle commercialization. From in-depth interviews with eleven experts, forty-four influencing factors were identified: twenty-nine of which are newly emerging factors, and fifteen are already established in the literature. Among these, four pull factors were confirmed, while twelve push factors were consistently highlighted by the experts. "Inexpensive product price for consumers" emerged as the most dominant pull factor in accelerating electric motorcycle commercialization, whereas the provision of incentives was the most frequently emphasized push factor driving supportive commercialization policies.

Keywords: Electric motorcycles; Commercialization; Pull factors; Push factors

1. Introduction

Currently, the primary source of global energy is fossil fuels, which have a significant environmental impact [1]. A quarter of energy comes from the transportation sector, which, if managed effectively, can help reduce greenhouse gases [2]. Efforts to lower greenhouse gases from the transportation sector can be significantly enhanced by replacing conventional transportation with electric vehicles (EVs) [3]. In addition, the environmental consequences of fossil fuel-powered vehicles have prompted a transition toward electric alternatives [4]. Emissions from the conventional vehicles and fossil fuels, combined with the energy crisis and the demands for energy efficiency, have made these issues increasingly urgent to discuss [5]. Moreover, the impact of climate change, energy consumption, and air quality is driving governments in various countries to accelerate the sale of EVs, while also generating economic benefits and creating jobs for new industries [6]. Therefore, various efforts have been made to accelerate the sale of electric vehicles globally.

Income levels exert a greater influence on the increase in electric motorcycle sales in developing countries than in developed countries [7].

Consequently, this condition has led to a rising demand for motorcycles in developing countries [8]. In many nations across Asia, Africa, and Latin America, motorcycles constitute the most common mode of transportation [9]. However, the high number of motorcycles has contributed significantly to carbon emissions. In several developing countries, including India, Vietnam, Thailand, and Indonesia, motorcycles are the primary contributors to high levels of carbon emissions [10]. Addressing this issue requires innovation to anticipate the environmental impact caused by carbon emissions produced by these vehicles. Therefore, accelerating the adoption of electric motorcycles in developing countries as a substitute for conventional motorcycles is a key strategy to achieve the global target of reducing carbon emissions.

Based on sales data from 2010 to 2018, the number of electric vehicle users worldwide is projected to reach 30% by 2032 [11]. Although the growth of electric vehicle sales worldwide is expected to accelerate over the next eight years, it is currently growing relatively slow. On the other hand, electric vehicle sales in China is projected to increase rapidly by more than 50% by 2025 [12]. Similarly, projections for electric motorcycle sales indicate positive developments from 2021 to 2030, reaching 5.7% growth in 2030 [10]. The motorcycle population across the Association of Southeast Asian Nations (ASEAN) member states has shown a consistent upward trend, especially in developing countries such as Indonesia, Vietnam, and Thailand. Among these countries, Indonesia records the highest number of motorcycles, with 134,181,607 units, followed by Vietnam with 58 million units and Thailand with 21 million units [13]. The predominance of motorcycles in transportation systems is largely due to the reliance on short-distance travel in metropolitan areas with high population density [14]. However, based on the electric vehicle sales data, Asia, China, India, and Vietnam accounted for the highest electric motorcycle sales in 2023, as illustrated in **Figure 1**.

Various policies have been implemented to encourage the adoption of electric vehicles among potential consumers, one of which is the provision of significant incentives [15], [16]. Nevertheless, the number of electric vehicles available globally reached only 1% by 2019 [15]. Despite their various advantages and positive impacts, the market share of electric vehicle sales remains low [17]. There are multiple challenges to accelerating the growth of electric vehicle sales, including the supply of materials that depend on imports and the availability of spare parts [18]. Furthermore, the development of electric vehicles faces various obstacles that hinder the acceleration of electric vehicle sales, including charging systems [1], selling prices, high initial investments, infrastructure, battery technology [19], manufacture for energy storage, negative customer perceptions [20], concerns about mileage, electricity networks, battery costs, additional expenses [21], battery lifespan, the need for fast-charging systems, cost-effectiveness [22], as well as technology and regulations [23].

Indonesia has set a target for the adoption of electric vehicles by 2030, comprising 2.45 million electric motorcycles and 600,000 electric four-wheeled vehicles. The country currently operates 76,000 public charging stations for electric vehicle batteries [24]. In addition, based on the latest data from the Indonesian Ministry of Energy and Mineral Resources, the government aims to have 2 million electric cars and 13 million electric motorcycles on the roads in Indonesia [25]. However, the adoption of electric vehicles in Indonesia remains low due to several challenges. According to data from the Indonesian Central Statistics Agency (Badan Pusat Statistik Indonesia), as of August 2024, the number of electric motorcycles had reached only 167,864 units. Market parameters and commercialization are among Indonesia's weaknesses in adopting

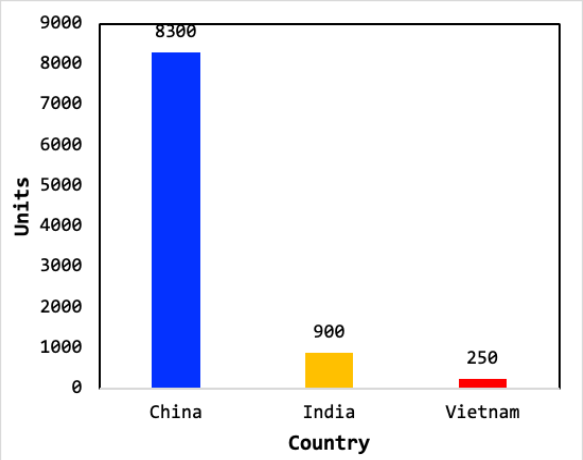

Figure 1. Highest-selling electric motorcycles in Asia in 2023 [26]

electric vehicles [27]. Furthermore, other challenges contributing to low market penetration in Indonesia must also be addressed during the transition to electric vehicles, including infrastructure, technology, economics, and consumer acceptance [28]. Therefore, this study is conducted to determine factors influencing the acceleration of electric motorcycle commercialization in developing countries, with a particular focus on Indonesia.

The main challenge in promoting electric motorcycle adoption in Indonesia lies on the demand side. Although Indonesia has a large population and is theoretically a significant market, the penetration rate of electric motorcycles remains very low. By early 2025, the adoption of new electric motorcycles is estimated to reach around 100,000 units, representing less than 1% of the total vehicles circulating in Indonesia [29]. This indicates that the domestic electric vehicle market is still at an early stage of growth and is facing stagnation in consumer demand [30]. A second challenge is the lack of an adequate ecosystem to support the use of electric vehicles in Indonesia. One crucial aspect is the availability of widely accessible charging infrastructure. As of March 2025, the number of Public Electric Vehicle Charging Stations (EV charging stations) for four-wheeled vehicles in Indonesia was recorded at 3,772 units, distributed across 2,515 locations throughout the archipelago, including Java, Sumatra, Kalimantan, Sulawesi, Bali, Nusa Tenggara, Maluku, and Papua [31]. Although this number shows significant progress, uneven distribution and varying operational readiness remain obstacles to increasing consumer trust and comfort in electric vehicles [32], [33], [34]. Therefore, research related to identifying commercialization factors for electric motorcycle products in developing countries—particularly Indonesia—remains necessary, acknowledging the potential for electric motorcycle expansion in these countries where conventional motorcycles currently dominate the market.

According to Angelina & Blagojce, 2012, essential factors in commercialization will be grouped into push factors and pull factors because the push and pull factor theory plays a critical role in encouraging and accelerating commercialization and investment [35]. This study further explains that push and pull factors are commonly applied in the study of international migration, which describes the causes of population movement from the countries of origin to the destination countries. However, in the context of economic activity, these factors can also be used to explain the motivations behind investment decisions in a company to accelerate commercialization or economic growth, for example identifying the factors of electric motorcycle commercialization by grouping pull and push identifying factors of electric motorcycle commercialization in developing countries, especially Indonesia [35].

Several researchers have conducted studies on electric vehicles. Veza *et al.* [36] investigated the challenges and opportunities of designing scenarios for the adoption of electric vehicles in Indonesia and Malaysia. A survey on electric vehicle policy adoption have focused on the effectiveness of policy to improve the number of electric vehicles [37], while other studies examined government policy about giving incentives to push the adoption of electric vehicles. In another study of electric vehicles, researcher explored connection technology and innovation in electric vehicles [38], while another study analyzed the development of technology for filling electric vehicles' infrastructure [34].

Existing literature on electric vehicles often overlooks electric motorcycles as a distinct area of study. Research on electric motorcycle conversions has been conducted by focusing on innovative products moving towards commercialization and examining the sustainability aspects of the engines used [39], [40]. However, electric motorcycle conversion differs from electric motorcycles, which have been designed as electric vehicles since the beginning of production. Therefore, research on more object-specific aspects of the electric motorcycle vehicle still needs to be developed. The classification of research topics is grouped into two main issues, namely electric vehicles and commercialization. The electric vehicle research area is categorized into three sub-areas: challenges and barriers, commercialization, and other related topics.

In comparison, the commercialization research area is divided into new product development (NPD) and product technology. The categorization is determined based on the

grouping of articles found on keyword searches. The field of study on electric vehicles, electric motorcycle conversion, and electric motorcycles is explained in **Table 1**.

Despite being a barrier to the adoption of electric vehicles, research on the commercialization of electric vehicles, particularly electric motorcycles, has been limited. Visually, the research gap in this area is illustrated in **Figure 2**. Previous studies on electric vehicles have examined the challenges, barriers, and push factors that influence electric vehicle adoption, but they have not specifically investigated vehicle commercialization as a driver of sales targets [30], [36], [41]. Meanwhile, research on product commercialization is more closely related to the

Table 1. Electric vehicle articles and commercialization

Reference	Scope	Objects	Electric Vehicles			Commercialization	
			Challenges & Barriers	Other Topics	Commerce	NPD	Product Technology
Huang *et al.* [14]	Government Policies	Electric Motorcycle	√	-	-	-	-
Habibie *et al.* [40]	Sustainable Evaluation of EM Conversion	Electric Motorcycle Conversion	√	-	-	-	-
Setiawan *et al.* [37]	Policies on Adoption	Electric vehicles	-	Adoption of Electric Vehicles	-	-	-
Maghfiroh *et al.* [38]	Stakeholders' Perception of Technology Readiness	Electric vehicles	-	Technology Readiness	-	-	-
Mastoi *et al.* [34]	Infrastructure and Policies	Electric vehicles	-	Infrastructure and Policy Readiness	-	-	-
Veza *et al.* [36]	Opportunities and Challenges	Electric vehicles	√	-	-	-	-
Ruan *et al.* [42]	Government's role	The electric bike	√	-	-	-	-
Stenroos and Sandberg [43]	Commercialization	New product development	-	-	-	√	-
Muda *et al.* [44]	Product Commercialization and Innovation	New product development	-	-	-	√	-
Habibie and Sutopo [39]	Commercialization Study	Electric Motorcycle Conversion	√	-	√		-
Ramesan *et al.* [41]	The challenges in the adoption	Electric vehicles	√	-	-	-	-
Habibie *et al.* [40]	Sustainability	Electric vehicles	√	-	-	-	-
Guerra [45]	EV Potential	Electric motorcycle	√	-	-	-	-
Mo *et al.* [46]	Commercialization	Electric vehicles	-	-	√	-	-
Soetopo [47]	Commercialization	Digital Technology	-	-	-	-	√
Latif *et al.* [48]	Commercialization	New product development				√	-
Martinez – Lao *et al.* [49]	Charging System	Electric vehicles	-	Infrastructure and Policy Readiness	-	-	-
Osorio *et al.* [50]	Charging System	Electric vehicles	-	Infrastructure and Policy Readiness	-	-	-

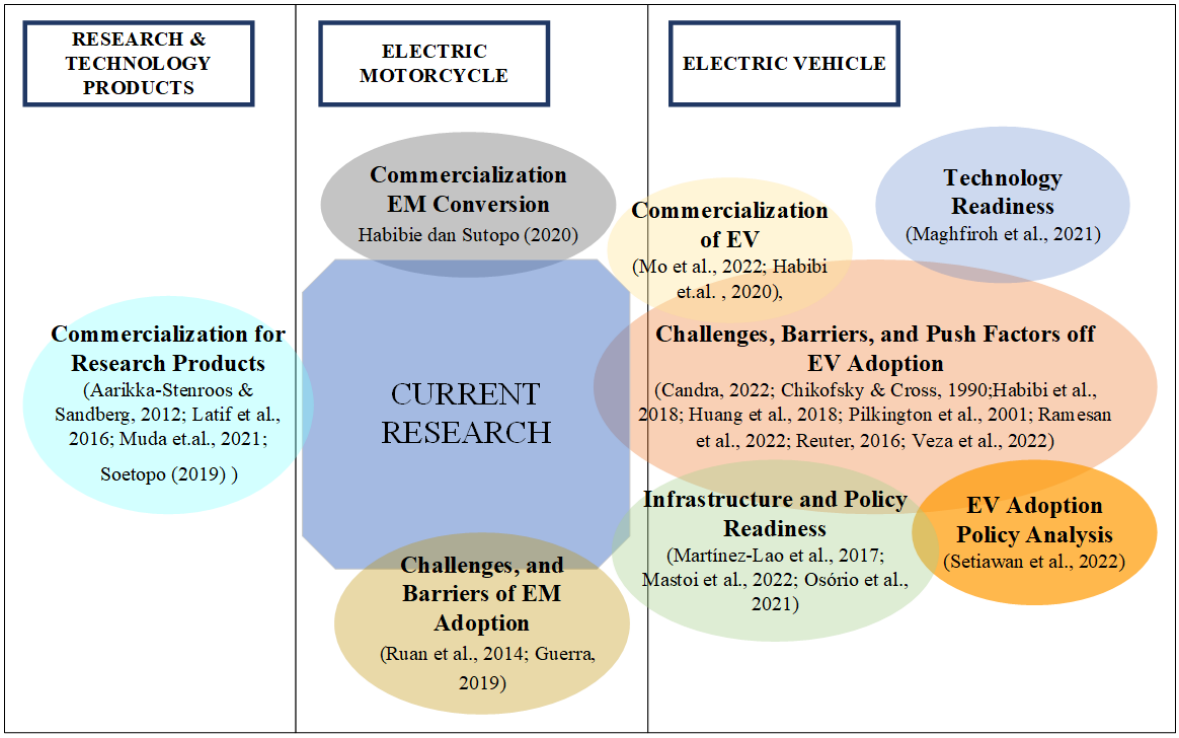

Figure 2. Research gap overview

development of new and technology-related products, as conducted by by several previous researchers. Research on commercialization for electric vehicles remains scarce. For instance, Mo *et al*. [46] conducted market research on electric vehicle commercialization, focusing on four key areas: government efforts to encourage growth, battery charging infrastructure, vehicle technology, and the discontinuation of electric vehicles. However, this research did not explore the possible factors influencing commercialization, and it was limited to the perspectives of customers and policy. In a study of electric motorcycles, Guerra [45] examined customer preferences for choosing electric motorcycles based on price, speed, range, and charging. Recent research on the electric motorcycle market has developed various subsidy and incentive policy scenarios aimed at reaching target markets [51]. Nevertheless, this research focuses solely on subsidy and emission penalty scenarios and their impact on market share. The exploration of factors was also limited to four factors that determine customer preferences. Thus, there remains a research gap in exploring factors that attract and drive the commercialization of electric motorcycles in Indonesia.

Several researchers have previously conducted studies to identify the current state-of-the-art and future research directions using bibliometric analysis [52], [53]. China has produced the highest number of publications on electric vehicles, with battery management systems, energy storage, and charging infrastructure being frequently discussed in studies over recent years [54], [55]. Other studies have focused on electric vehicle trends, policy implications, lithium-ion batteries, and battery management systems, emphasizing the need for synchronization of international electric vehicle policies, advancement in battery technology, and the promotion of research [56]. Studies on electric vehicle adoption have also highlighted customer behavior, highlighting that electric vehicle charging infrastructure and service facilities are key factors in the adoption of electric vehicles. Despite these contributions, there remains a gap in bibliometric analysis research focusing on the commercialization of electric vehicles. Therefore, one of the questions addressed in this paper is to identify the current state of the art and future research opportunities in the field of electric vehicle commercialization. This study aims to examine the development and research potential of electric motorcycles commercialization and to identify the pull and push factors that accelerate the commercialization of electric motorcycles in Indonesia.

2. Methods

This study employed an exploratory approach and conducted in-depth interviews with experts as part of comprehensive research on electric motorcycles. An exploratory study was conducted using bibliometric analysis software and a scoping literature review. Details are shown in **Figure 3**.

2.1. *Identification of Potential Research*

The identification of research potential was conducted using a bibliometric analysis approach, which aimed to assess the topic's potential at the time of study. This bibliometrics analysis utilized the biblioshiny R software version 4.3.1. A bibliometric analysis was conducted using the Scopus database, employing the search criteria outlined in **Table 2**.

2.2. *Identification of Commercialization Factors*

The study employed a literature review approach with a scoping review. This method was selected because it aligns with the research objective of mapping the literature within a specific topic area [57]. Scoping literature reviews can also be used to identify research gaps,

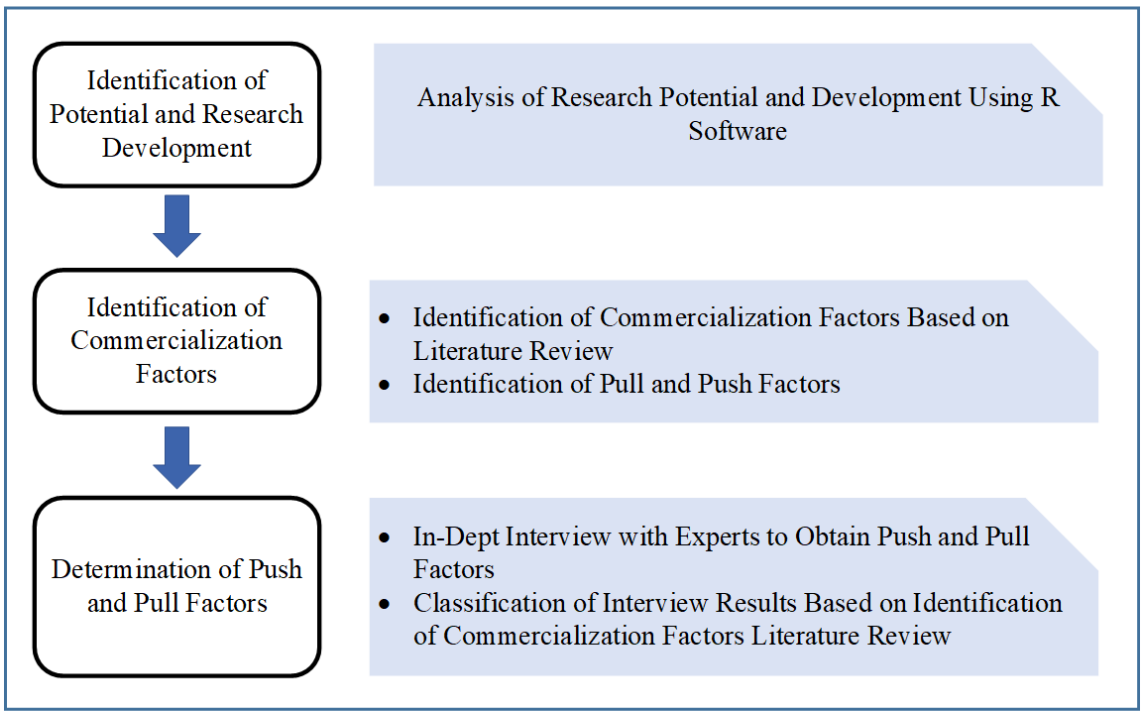

Figure 3. Research framework

Table 2. Scopus database search criteria and search results

	Article Grouping	Selected Documents
Title, article, abstract, keywords	(TITLE-ABS-KEY ("Electric motorcycle" OR "Electric motorcycle" OR "Electric motorcycles" OR "Electric motorcycles" OR "electric motor vehicle" OR "electric motor vehicles")	756 Documents
	TITLE-ABS-KEY ("Electric motorcycle" OR "Electric motorcycle" OR "Electric motorcycles" OR "Electric motorcycles" OR "electric motor vehicle" OR "electric motor vehicles") AND TITLE-ABS-KEY (commercialization OR commercialization OR commerce OR sales OR marketing OR market)	118 Documents
Document Type, Stage Publication, Language	Journal and Conference Proceedings Final Stage English	106 Documents:
Year	2015 – 2025	87 Documents

providing a comprehensive review of the limitations in the existing literature and enabling the exploration of complex and broad research topics [58]. In addition to serving as a foundation for designing a research agenda and developing research in a particular field, scoping literature reviews provides valuable insights for informed decision-making [59]. Therefore, a scoping literature review is particularly relevant to the limited research on electric vehicle commercialization, which lacks sufficient references, and it is consistent with the research objective of exploring the push and pull factors for the future commercialization of electric motorcycles.

The identification process was conducted using selected articles and research topics related to electric vehicles, electric motorcycles, and commercialization. Although the study focuses on the commercialization of electric motorcycles, this emphasis is due to the relatively limited research available in this area. In addition, the identification factors of commercialization were also examined through a literature review of studies on electric vehicles and other technology-based products. The results of this stage are expected to identify the driving factors for the commercialization of electric vehicles in general.

2.3. *Determination of Pull and Push Factors*

The expert approach in this study involved in-depth interviews supported by a questionnaire. The interview was open-ended, allowing for discussion of both Pull and Push Factors that can accelerate the commercialization of electric motorcycles. The selection of experts was guided by the triple helix concept, which includes representatives from universities, industry, and government [60]. This concept aligns with the study's objectives, which are dynamic, comprehensive, and practical for the policy framework related to the commercialization of electric motorcycles. Given the limited number of expert sources in electric motorcycles research, which is still in its early stages of development in Indonesia, the number of experts involved was determined accordingly. However, the background of the selected experts fulfilled the triple helix aspect, comprising professors and researchers of electric motorcycles at universities, researchers at government agencies and the Ministry of Industry, and practitioners in the electric motorcycles industry in Indonesia. Validation of the interview results with the qualitative results was carried out by comparing the interview results with the findings of the literature review conducted [61].

The following pull and push factors were classified based on the commercialization factors identified in the previous stage. Each factor was then analyzed based on the data provided by the experts. In selecting the relevant factors, the expert emphasized those most frequently associated with commercialization. Those were subsequently categorized as Pull and Push Factors to be considered in accelerating the commercialization of electric motorcycles.

3. Results and Discussion

This section presents research findings, including the global development of research on the commercialization of electric motorcycles, the key factors influencing commercialization, the identification of pull and push factors for accelerating the commercialization of electric motorcycles, and the most dominant pull and push factors in accelerating the commercialization of electric motorcycles.

3.1. *Identification of Research Potential*

The results of the scientific production analysis indicate that the number of research articles with the specified keywords increased by approximately 23.11% from 2015 to 2025. These results present the factors contributing to the successful commercialization of electric motorcycles. Based on the thematic map in **Figure 4**, five thematic categories can be identified. Group 1, represented by the purple circle, is classified as a basic theme and includes topics such as commercialization, battery pack, lithium-ion battery, battery capacity, and the automotive industry. Groups 2 and 3 are positioned between the motor themes and the basic themes. Group 2, represented by the magenta circle, covers topics such as electric motorcycles, electric scooters, sales, purchase intention, and competition. Group 3, represented by the green circle, includes Indonesia, case studies, charging (batteries), charging infrastructures, and carbon emissions. Meanwhile, Group 4, represented by the orange circle, focuses specifically on motor-related

themes, including secondary batteries, fossil fuels, greenhouse gases, life cycle analysis, and global warming. Finally, Group 5, represented by the blue circle, falls between the motor themes and niche themes and includes electric vehicles, cycle transport, consumer behavior, economic analysis, and environmental economics. Its research potential is based on themes, as its level of development is low while its level of relevance is high.

The thematic evolution in **Figure 5** illustrates studies on topics related to electric motorcycles. Since 2023, research has expanded into several new areas, including electric motorcycles, commercialization, carbon emissions, economic and social effects, competition, battery, and internal combustion engines. Research on commercialization has partly evolved from the topics of charging (batteries), battery packs, and electric motorcycles. Similarly, research on electric motorcycles has evolved into two primary topics: electric motorcycles and commercialization. Other emerging issues include carbon emissions, economic and social effects, competition, and internal combustion engines.

The cluster analysis in **Table 3** identifies 4 clusters. Cluster 1 includes: electric motorcycles, Indonesia, electric scooters, sales, charging (batteries), charging infrastructures, internal combustion engines, purchase intention, competition, energy efficiency, battery, charging stations, economic and social effects, adoption intention). Cluster 2 includes: electric vehicles, cycle transport, life cycle analysis, Taiwan, consumption behavior, financial analysis, environmental economics, sustainability, willingness to pay). Cluster 3 involves: battery pack, commercialization, lithium-ion battery,

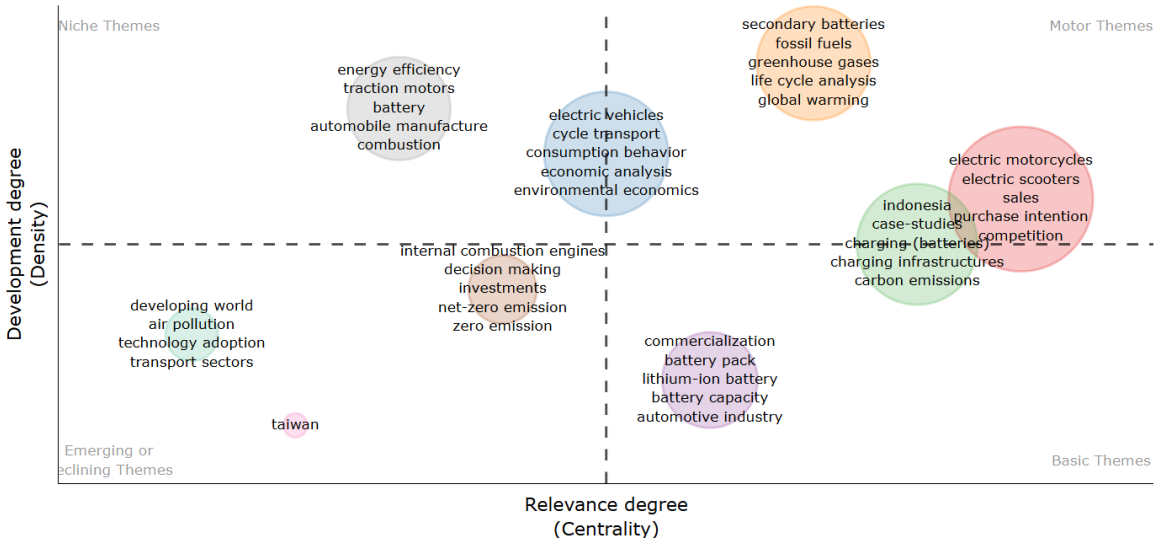

Figure 4. Thematic map (Source: R.4.3.1 Software)

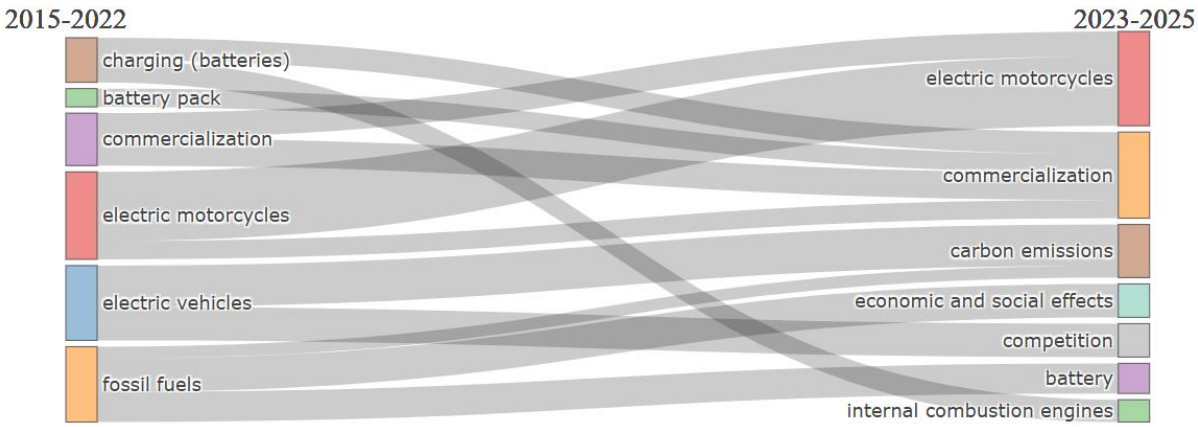

Figure 5. Thematic evolution (Source: R.4.3.1 Software)

Table 3. Co-occurrence network (Source: R.4.3.1 Software)

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Electric Motorcycles	Electric Vehicles	Battery Pack	Secondary Batteries
Indonesia	Cycle Transport	Commercialization	Fossil Fuels
Electric Scooters	Life Cycle Analysis	Lithium-Ion Battery	Greenhouse Gases
Sales	Taiwan	Global Warming	Sustainable Development
Charging (Batteries)	Consumption Behavior	Traction Motors	Charging Time
Charging Infrastructures	Economic Analysis	Battery Capacity	Costs
Internal Combustion Engines	Environmental Economics	Modeling	Gas Emissions
Purchase Intention	Sustainability	-	-
Competition	Willingness To Pay	-	-
Energy Efficiency	-	-	-
Battery	-	-	-
Charging Stations	-	-	-
Economic And Social Effects	-	-	-
Adoption Intention	-	-	-

global warming, traction motors, battery capacity, modeling). Meanwhile, Cluster 4 comprises: secondary batteries, fossil fuels, greenhouse gases, sustainable development, charging time, costs, gas emissions. Research on commercialization has partly evolved from the topics of charging (batteries), battery packs, and electric motorcycles.

The results of the clustering analysis revealed several keywords related to research on the commercialization of electric motorcycles outside of the keywords used in the search, namely charging (batteries), charging infrastructure, charging station, purchase intention, energy efficiency, consumption behavior, cycle transport, willingness to pay, sustainability, lithium-ion battery, global warming, charging time, cost, gas emissions, and other keywords. These keywords have the potential to be considered in investigating factors that can accelerate the commercialization of electric motorcycles. Through a more in-depth literature review, these factors can be further classified as pull and push factors to accelerate the commercialization of electric motorcycles.

3.2. *Identification of Commercialization Factor*

Based on a literature review of commercialization factors for electric vehicles, electric motorcycles, and several products utilizing similar technology, 27 journal articles and international proceedings indexed by Scopus were identified. These studies encompass 17 factors related to electric vehicle and product commercialization. The results of the factors determining commercialization and electric vehicles are presented in Table 4.

Furthermore, these factors can be taken into consideration in determining the commercialization of electric motorcycles in Indonesia. In more detail, these factors are explained in Table 5.

The next step was identifying the influential factors in commercialization. This step was investigated deeper, involving experts from academia, practitioners, and government who had experiences in the field of automotive technology, particularly electric vehicles.

3.3. *Pull and Push Factor Identification*

This stage involved experts from various backgrounds, including practitioners from industry, academics from universities, researchers, and government officials. Several criteria were set to determine the expert's eligibility, including relevant expertise and work experience, while ensuring compliance with the triple helix aspects. The selected experts possessed a minimum of five years of work experience, held a minimum position of manager or equivalent, demonstrated knowledge of factors influencing the success of electric motorcycle commercialization in Indonesia, and were familiar with electric motorcycle development policies in Indonesia including the selection of effective policy strategies and priorities. A total of 11 experts participated in the study, with a proportional distribution of expert backgrounds, as detailed in Table 6.

The approach involving experts includes interviews and open-ended questionnaires to identify commercialization factors for electric motorcycles, which are categorized into Pull and

Table 4. Identification of factors or success factors in the commercialization of electric products and vehicles

Refs.	Commercialization																
	Price	Production Cost	Marketing Strategy	Business Partners	Environment / Health	Social	Regulation	Incentive	Development Products / Innovations	Technology	Mileage	Time	Speed	Quality	Ergonomics	Distribution	Infrastructure
Huang *et al*. [14]	√	-	-	-	-	-	-	√	-	-	-	-	-	-	-	-	-
Luansing *et al*. [62]	√	-	-	√	-	-	√	-	-	-	-	-	-	-	-	√	-
Istiqomah *et al*. [63]	√	-	-	-	-	-	√	-	-	-	-	-	-	-	-	-	√
Setiawan *et al*. [37]	-	√	-	-	√	-	√	√	-	-	-	-	-	√	-	-	√
Maghfiroh *et al*. [38]	-	-	-	-	-	-	-	√	-	√	-	-	-	-	-	-	-
Mastoi *et al*. [34]	-	-	-	-	-	-	-	-	-	√	-	-	-	-	-	-	-
Veza *et al*. [36]	-	-	-	-	-	-	√	-	-	√	-	-	-	-	-	-	√
Sanguesa *et al*. [64]	-	-	-	-	-	-		-	-	√	-	-	-	-	-	-	-
Ruan *et al*. [42]	-	-	√	-	-	-	√	-	-	-	-	-	-	-	-	-	-
Stenroos and Sandberg [43]	-	-	√	√	-	-	-	-	-	-	-	-	-	-	-	√	-
Yuniaristanto *et al*. [65]	-	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Muda *et al*. [44]	-	-	-	√	-	-	√		-	-	-	-	-	-	-	-	-
Habibie and Sutopo [39]	-	-	-	-	-	-	√	-	-	-	-	-	-	-	-	-	√
Ramesan *et al*. [41]	-	-	-	-	√	-	√	-	-	√	-	-	-	-	-	-	-
Martinez-Lao *et al*. [49]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	√
Osório *et al*. [50]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	√
Oryani *et al*. [66]	√	-	-	-	√	-	-	-	-	-	-	-	-	√	-	-	-
Lim [67]	-	-	√	√	√	-	-	-	√	-	-	-	-	-	-	-	-
Habibie *et al*. [40]	-	√	-	-	√	√	-	-	-	√	-	-	-	-	-	-	-
Ismail *et al*. [68]	-	-	√	√	√	-	-	-	√	-	-	-	-	-	-	-	-
Srikandi *et al*. [69]	√	-	-	-	√	-	-	-	-	-	-	-	-	√	-	-	-
Chu *et al*. [70]	-	√	-	-	√	-	-	-	√	√	-	-	-	-	-	-	√
Yang *et al*. [71]	-	-	-	-	-	-	-	-	√	-	-	-	-	-	-	-	-
Soetopo [47]	-	-	-	-	-	-	-	-	√	-	-	-	-	-	-	-	-
Cho and Lee [72]	-	-	√	-	-	-	-	-	-	-	-	-	-	√	-	-	-
Ziegler and Abdelkafi [73]	√	-	-	-	-	-	-	-	-	-	-	-	-	√	-	-	-
Guerra [45]	√	-	-	-	-	-	-	-	-	-	√	√	√	√	√	-	-

Table 5. Description of each factor

Commercialization Factors	Description
Price	Comparison of electric vehicle prices with conventional vehicles [14]
Production cost	Costs allocated for maintenance, manufacturing, operations, and production expenses for other steadfast and loyal customers [37]
Marketing strategy	Strategies for selling electric vehicles, including promotion, expanding market share, and increasing customer satisfaction [67]
Business Partners	Building partnerships with local government and businesses [44]
Environment / Health	Pollution from vehicles emissions which impacts environmental cleanliness and health [41]
Social	Factors related to society and characteristics of community or lifestyle [40]
Regulation	Regulation on tax incentives from the government [37]
Incentive	Incentives for the industry, automotive, and customers to encourage the acceleration and adoption of electric vehicle [14], [37], [38]
Development Products / Innovations	Innovation of a suitable product that align with the customer expectations [71]
Technology Readiness	Readiness to adopt the latest technology [41]
Mileage	The distance that can be covered by a vehicle [37]
Time	The time required to charge an EV battery [45]
Speed	Vehicle performance on terms of speed over distance [45]
Quality	Quality of vehicle electricity [37]
Ergonomics	Safety issues from electric vehicles [45]
Distribution	Distribution channels for fulfilling the customer needs [43]
Infrastructure	Infrastructure readiness of charging infrastructure at various location [37]

Table 6. Profile expert respondent

Expert	Profile	Institution
1	Professor and Researcher	State University, Ex. Head of EV Research Center
2	Academic, and Practitioner (Owner)	State University, Private Company
3	Academic and Researcher	Private University
4	Senior Researcher	National Research and Innovation Agency
5	Ministry of Industry	Government
6	Ministry of Industry	Government
7	General Manager	Automotive Company
8	Director	Electric Motorcycle Conversion Company
9	Manager	Battery Technology Company
10	Marketing	EV Battery Manufacturer
11	General Company	Electric Vehicle Company

Push Factors. These factors are illustrated in **Figure 6** and **Figure 7**. Regarding the pull factors for electric motorcycle commercialization, as shown in **Figure 6**, several new findings were identified through the perspectives of experts from academia, government, and business actors. Experts emphasized that, in the case of electric motorcycles, consumers should be able to cover the purchase price or associated costs through installment systems.

One identified factor relates to higher operational and maintenance costs, which, nevertheless, can result in greater long-term savings. In the speed category, torque and maximum speed should be considered as important factors for electric motorcycles. In the design category, ergonomics should be a factor in security products and convenience operations. In this category, the battery is expected to be a high-capacity battery. Regarding the travel distance, convenience in battery charging should be prioritized, including the availability of charging stations equipped with various types of sockets, as well as systems that allow battery swapping or exchange, thus it can eliminate the need to wait for charging. Additionally, the use of durable batteries with a lifespan of approximately five years should also be considered.

Regarding the push factors in commercialization, as illustrated in **Figure 7**, several new factors were identified based on confirmation from experts representing academia, government, and business actors. Experts added that electric motorcycles should be prominently featured in advertising within the commercialization market category. Another important factor is consumer and public education, which is essential to raise awareness that electric motorcycles represent a viable alternative to conventional motorcycles. In addition, transportation was identified as a critical factor, encompassing both public and private sectors. The development of an electric vehicle ecosystem by the government should therefore begin with the integration of electric motorcycles into public transportation services, followed by adoption in private transportation.

In the category of regulation or policy, there are incentives factor consisting of various types of incentives. Experts argue that, in addition to incentives for consumers, factors such as incentives for the company, tax reductions for Public Electric Vehicle Charging Stations (EV charging station or SPKLU), minimum consumer tax, and minimum corporate tax also support the commercialization of electric motorcycles. The Local Content Requirement (LCR or TKDN) factor, previously set at 60%, has been replaced with standard minimum investment and restrictions, which can significantly impact the success of commercialization of electric motorcycles.

In regard to the category of consumer awareness, education within communities is crucial to emphasize that electric vehicles are superior to conventional vehicles and that accessibility is an important factor. This awareness strongly determines the success of electric motorcycle commercialization. In the social and cultural category, experts note that existing communities also influence usage trends in electric motorcycles and shape public perceptions. Finally, in the infrastructure category, experts highlight that EV charging stations provide numerous services in one place. The availability of battery swapping systems and

standardized chargers increases consumer interest in electric motorcycles, as they enable convenient and accessible power refilling.

According to experts, in addition to offering multiple services, EV charging stations should also ensure the availability of a reliable electricity supply. In the distribution management category, dealers, workshops, services, finished sales, and warranties are available to determine the success of commercializing electric motorcycles.

3.4. *Pull and Push Factors*

In this stage, the factors identified previously were quantified based on the results of the expert interviews. The criteria and profiles of the experts are presented in **Table 5**. Each expert participated

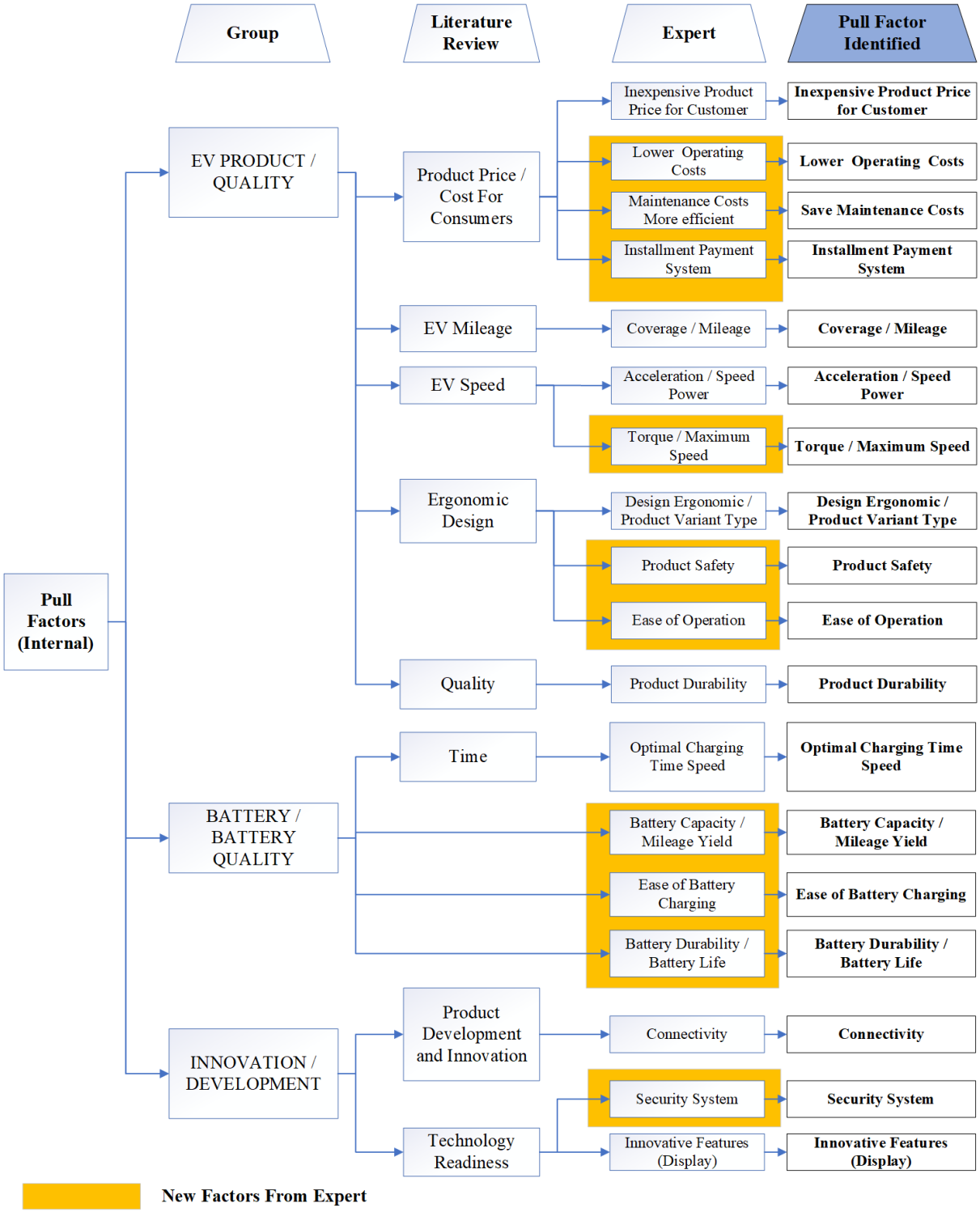

Figure 6. Pull factors

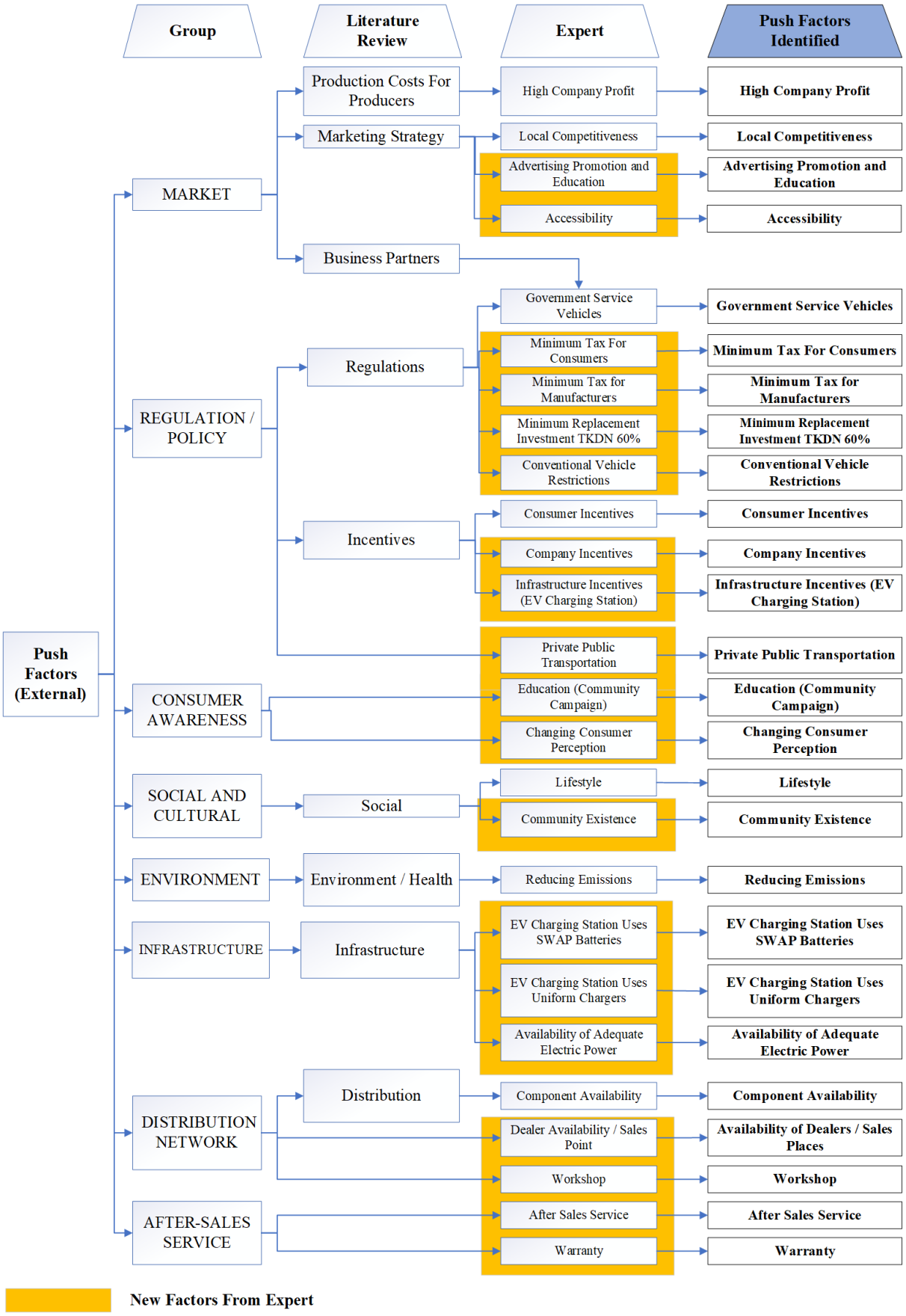

Figure 7. Push factors

in an in-depth interview lasting approximately one to two hours, using open-ended questions to obtain comprehensive insights. The interviews yielded qualitative data that were subsequently categorized into commercialization factors: pull and push factors. The push and pull factors listed in **Table 7** were selected based on their frequency of mention by at least two experts. The percentage of each factor was calculated based on the number of experts mentioning the factor relative to the total number of experts involved in the study.

3.5. Discussion

Based on the thematic map analysis, research on commercialization is more often conducted alongside studies on battery. This research field remains relatively underdeveloped but has a high level of relevance. These results suggest that commercialization remains a relevant topic and requires further exploration. In contrast, research on electric motorcycles has advanced significantly, with a higher level of relevance compared to commercialization. This topic is situated in the same research group as sales, purchase intention, and electric scooters. These results highlight that research on electric motorcycles remains highly relevant for further development, presenting an opportunity for further research on commercialization, which occupies a distinct category.

The results of the thematic evolution analysis indicate that commercialization and electric motorcycles remain relevant, as new topics continue to emerge. Commercialization topic is more often associated with research on electric vehicle batteries than with electric motorcycles as the final product. Meanwhile, the clustering analysis results based on the co-occurrence network clarify the grouping or clustering results of the topics, showing that electric motorcycles topic still has potential for exploration in conjunction with commercialization, as it falls into a different research cluster. This result reinforces the novelty of research on the commercialization of electric motorcycles. The clustering results also reveal several keywords that may represent critical factors in commercialization of electric motorcycles and merit further investigation. These include charging (batteries), charging infrastructure, charging station, purchase intention, energy efficiency, consumption behavior, cycle transport, lithium-ion battery, global warming, charging time, cost, gas emissions, and other related terms.

Table 7. Expert opinion on driving factors and pull factors for the commercialization of electric motorcycles

	Factors Identified	Expert											Total	
		1	2	3	4	5	6	7	8	9	10	11	Experts	%
Pull	Inexpensive Product Price for Customer	▫	▫	▫	▫	-	▫	▫	▫	▫	▫	▫	10	90.91%
	Lower Operating Costs	-	-	-	-	▫	-	-	-	▫	-	▫	3	27.27%
	Design Ergonomic / Product Variant Type	-	▫	-	▫	-	-	-	▫	-	-	-	3	27.27%
	Optimal Speed Charging Time	-	-	-	▫	-	-	-	-	▫	-	-	2	18.18%
Push	High Company Profit	▫	▫	▫	-	-	-	-	-	-	-	-	3	27.27%
	Government Service Vehicles	▫	▫	▫	-	-	-	-	-	-	-	-	3	27.27%
	Private Public Transportation	▫	▫	-	-	-	-	-	-	-	-	▫	3	27.27%
	Consumer Incentives	▫	▫	▫	-	▫	▫	-	▫	-	▫	▫	8	72.73%
	Company Incentives	▫	▫	▫	-	-	-	-	▫	-	-	▫	5	45.45%
	Infrastructure Incentives (EV Charging Station)	-	-	▫	▫	-	-	-	-	-	-	-	2	18.18%
	Minimum Tax for Consumers	▫	▫	▫	▫	▫	▫	▫	-	-	-	-	7	63.64%
	Minimum Tax for Manufacturers	-	-	▫	-	-	-	-	▫	-	-	-	2	18.18%
	Minimum Replacement Investment Local Content Requirement (LCR) 60%	-	-	▫	▫	-	-	-	-	-	-	-	2	18.18%
	Reducing Emissions	-	-	-	-	-	-	-	▫	-	▫	▫	3	27.27%
	EV Charging Station Uses Uniform Chargers	-	-	▫	-	▫	▫	-	-	▫	▫	-	5	45.45%
	After Sales Service	▫	-	-	▫	-	-	-	-	-	-	-	2	18.18%

Based on the identification of commercialization factors obtained from the literature review analysis, 17 factors were identifies across 40 articles: price [14], production cost [63], marketing strategy [67], business partners [44], environment and health [44], social [40], regulation [38], incentive [14], development products and innovations [71], technology readiness [36], mileage [37], time [45], quality [66], ergonomics [45], distribution [62], and infrastructure [39]. According to Guerra [45], consumer willingness to adopt electric vehicles is influenced by several factors, including price, speed, power, range, charging time, quality, and is very important in determining preferences and potential demand for adopting electric vehicles. Similarly, Veza *et al*. [36] highlights that the opportunities and challenges of electric vehicles in Indonesia and Malaysia are influenced by several factors, including: the distribution of components, workplace safety issues, efficiency, comfort, accessibility, and policies.

Based on the expert results, the factors obtained from the literature review can be categorized into Pull Factors and Push Factors. Pull factors refer to internal or attractive elements that accelerate the commercialization of electric motorcycles. In contrast, the push factor is an external factor that accelerates the commercialization of electric motorcycles.

Following the interviews and questionnaires, several additional pull and push factors were identified. The push factors in the commercialization of electric motorcycles include not only their affordable price but also several additional advantages, such as low operating costs, low maintenance costs, installment payment options, strong torque and high speed, product safety, and ease of use when operating the motorcycle. There are new factors in battery category, namely battery capacity or maximum battery mileage, ease of charging, and the ability to maintain a relatively long battery life.

Pull factors that can be considered in the policy framework for the commercialization of electric motorcycles include market-related aspects such as the high selling price set by companies. Additionally, new factors such as advertising for education and private public transportation (online motorcycle taxis) are also worth considering. Within the category of regulations or policies, in addition to consumer incentive factors or sales incentives, there are new factors, namely company incentives, incentives for EV charging station (public electric vehicle charging station), minimum taxes for consumers, minimum taxes for producers, Local Content Requirement (LCR) which is 60% replaced by Company investment, restrictions on conventional vehicles, community education or campaigns on the benefits of using electric motorcycles, and easy accessibility for electric motorcycle users.

In social and cultural categories, in addition to lifestyle, new factors include the existence of communities and perceptions that change the community's mindset. For infrastructure, in addition to EV charging stations, there are several new considerations including the use of SWAP batteries, uniform chargers, adequate electricity availability, and the availability of dealers or retail outlets. Furthermore, within SCM or distribution networks, there are new factors in addition to the availability of components, namely dealers, workshops, services, finished sales, and warranties on electric motorcycles.

Of the 44 factors identified, more than one expert highlighted four pull factors and twelve push factors. Among the pull factors, ten experts (more than 90% of the experts) identified the inexpensive product price as a key benefit for customers. This factor is the most dominant and is a pull in accelerating the commercialization of electric motorcycles. These results align with research on the influence of subsidy policies on electric motorcycle market share, which demonstrated that purchasing subsidies and electricity subsidies can significantly influence electric motorcycle adoption [51]. This study also demonstrated that infrastructure and tax incentives influence policies that support the adoption of electric motorcycles. Other research on electric vehicle adoption and production also suggests that price subsidies and incentives play a role in supporting the electric vehicle ecosystem [74]. Meanwhile, more than 45% of the experts mentioned four push factors: consumer incentives, corporate incentives, minimum taxes for consumers, and EV charging stations that implement standardized fees. Incentives emerged as the factor most often mentioned by experts as a driver of accelerating the electric motorcycles commercialization. This factor indicates that

when designing policies to accelerate the commercialization of electric motorcycles, this factor should be considered by stakeholders.

Previous research has demonstrated a relationship between push and pull factors in the commercialization of electric vehicles. Providing incentives to the automotive and related industries can accelerate EV product innovation. Moreover, tax incentives may serve as an alternative mechanism to attract investors, increase capital, and lower production costs. Therefore, further research on the interrelationships among these factors in designing policies to accelerate commercialization is highly recommended.

4. Conclusion

Research on commercialization and electric vehicles has increased significantly over the last decade. Results from bibliometric analysis using software indicate that research on the commercialization of electric vehicles is a promising area to explore in more depth. Based on the author's country of origin, few researchers in Indonesia have investigated the commercialization of electric motorcycles, despite the considerable market potential and country's large population. The results of the clustering analysis with bibliometrics reveal opportunities to integrate several potential research topics for development, including cluster 1 (electric motorcycles) and cluster 3 (commercialization). Keyword analysis reveals several terms frequently discussed in the context of commercialization and electric vehicles, including costs, investment, sales, competition, policies, infrastructure, and demand.

Meanwhile, the results of the SLR analysis identify 17 key factors in the commercialization of electric vehicles, which can serve as a reference for electric motorcycles. However, to identify and validate these factors, further research is needed by involving experts in the commercialization and electric motorcycle industry, including entrepreneurs, industry players, manufacturers, policymakers, and stakeholders with diverse interests. According to the literature review, 17 factors have been identified as contributing to the successful commercialization of electric motorcycles. Building on these findings, the researcher conducted interviews and administered an open questionnaire regarding the success factors influencing commercialization of electric motorcycles. From this process, an additional 44 factors were identified by the experts, which were categorized into pull factors and push factors to accelerate the commercialization of electric motorcycles. Based on the observations from 11 experts, four pull factors were obtained, and more than one expert mentioned 12 push factors. Among these, inexpensive product price for customers is the most dominant factor in accelerating the commercialization of electric motorcycles. Meanwhile, the provision of incentives is the most frequently cited by experts as it drives the acceleration of electric motorcycle commercialization.

Research on electric motorcycles has been increasing, particularly in developing countries. However, the topic of commercialization requires further development to encourage the growth of electric motorcycle sales globally. The results of research on these pull and push factors are the basis for designing commercialization policies. Further research is still needed to process these factors into a policy. Additional research on electric motorcycle commercialization policies can be developed using various methods, such as dynamic systems and decision-making techniques.

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Author's Declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

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Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interest.

Additional information

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