

**Analyzing the Factors Influencing Electric Vehicle Adoption in Indonesia:
An Interpretive Structural Modelling (ISM) Approach**

UNDERGRADUATE THESIS

**Submitted to the International Undergraduate Program in Industrial Engineering in
Partial Fulfillment of the Requirement for the Degree of Sarjana Teknik at the Faculty
of Industrial Technology
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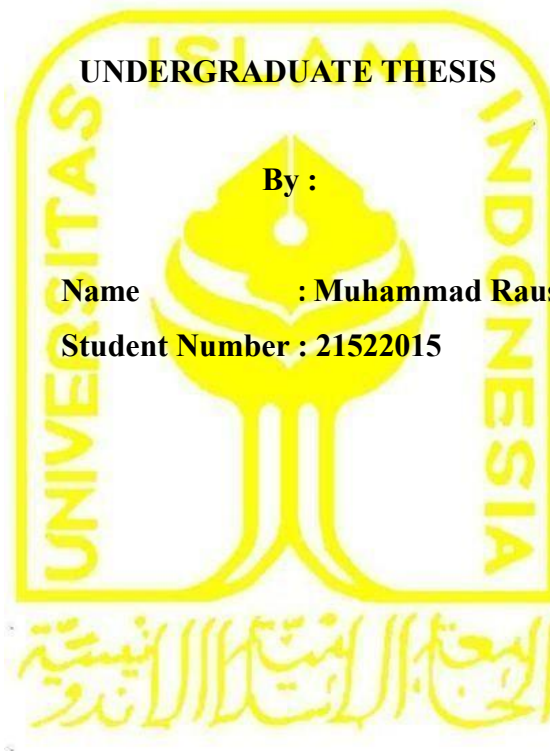
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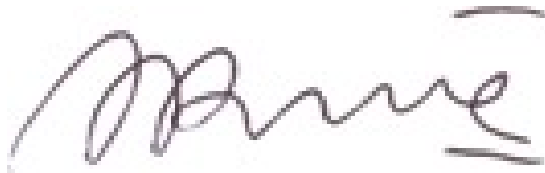
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An Interpretive Structural Modelling (ISM) Approach

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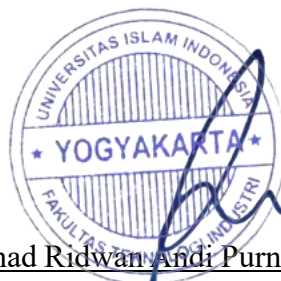
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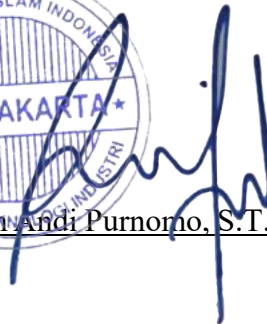
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DEDICATION PAGE

This thesis is wholeheartedly dedicated to my beloved parents, whose love, sacrifices, and unwavering prayers have been my greatest source of strength. Every step I take, every challenge I face, they are always behind me, providing encouragement and hope. Without their sincere support, I wouldn't be where I am today. They are the true heroes of my life, and without them, this achievement would not have been possible.

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Without the guidance, unwavering faith, and love of those around me, this accomplishment would not have been achievable. They are the reason I have been able to persevere, grow, and reach this point. With the utmost respect and gratitude, I dedicate this thesis to those who have always been in my life, offering their love, sacrifices, and endless support.

MOTTO

“Allah does not burden a person but according to his ability.”

(Q.S Al- Baqarah: 286)

“Regarding smart work that requires more effort, Allah SWT will never test His servants beyond their limits. Even so, we often give up before that limit. ”

(Ayah)

“Dunia boleh saja menahanku, kupunya doa ibu.”

(Perunggu)

PREFACE

Assalamu'alaikum Warahmatullahi Wabarakatuh.

Alhamdulillah, all praise be to Allah Subhanahu Wa Ta'ala for His Grace and blessings, so that the author can complete the Final Assignment and preparation of the report entitled "Analyzing the Factors Influencing Electric Vehicle Adoption in Indonesia: An Interpretive Structural Modeling (ISM) Approach" in order to fulfill one of the requirements in obtaining a Bachelor's degree in the Industrial Engineering study program, Faculty of Industrial Technology, Universitas Islam Indonesia. Not to forget the author's prayers and greetings always be conveyed to the Prophet Muhammad Shallallahu 'Alaihi Wa Sallam along with his family, friends and followers until the end of time who have struggled and guided us from the dark ages to the bright realm to achieve the pleasure of Allah Subhanahu Wa Ta'ala.

In compiling this final assignment, the author would like to express his deepest gratitude and appreciation to all parties who have provided guidance and motivation in completing this report. Therefore, the author would like to express his gratitude to:

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4. My parents, my father and mother, who always pray for me and support me in everything. I hope that the completion of this study period will bring them happiness and pride, even though this achievement cannot be compared to all the sacrifices they have made. May this success be a small reflection of the immense love and guidance that always accompany me every step of the way.
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7. For every soul that has caused me sorrow, and every soul I have burdened with my own, your presence lives quietly within my strength and has become the deep current that carried this report to its end.

Finally, the author realizes that this report is far from perfect and has various shortcomings. Therefore, the author greatly appreciates constructive criticism and suggestions as valuable input for future improvements.

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ABSTRACT

The automotive industry plays a crucial role in Indonesia's development, by contributing to economic growth and employment. However, the environmental impact of conventional vehicles necessitates a shift to more sustainable alternatives. This research helps identify and analyze key factors influencing electric vehicle adoption in Indonesia, focusing on supply chain challenges, policies, cultural preferences, logistics, and infrastructure. Using CVI as a validation method and an Interpretive Structural Modelling (ISM) approach, this study offers a systematic understanding of the interrelationships between these factors. These findings will help policymakers, manufacturers, and supply chain operators formulate effective strategies to address these challenges. This research is crucial for accelerating the transition to electric vehicles, reducing carbon emissions, and promoting a more sustainable transportation system in Indonesia. Based on the results provided, several key factors were found that the connectivity of the items was interrelated.

Keywords: CVI, EV' Industry, Interpretive Structural Modelling, Indonesia

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CHAPTER 1

INTRODUCTION

1.1 Background

Indonesia keeps growing, especially with the significant rise of the automotive industry in the recent decade (Bank, 2019) which greatly affects the environment. This affects the emission of air pollutants because higher carbon dioxide (CO₂) emissions have caused air pollution to worsen rapidly (Hasanah, 2023). Recognizing this, the Indonesian government has implemented laws and incentives to promote EV adoption, including tax breaks, infrastructure development plans, and industry incentives (Dzikri Firmansyah Hakam, 2023). Despite these efforts, the adoption of electric vehicles remains slow, due to (Aditya Mahalana, 2023) high vehicle costs and according to other authors (Candra, 2022) limited public awareness, underdeveloped charging infrastructure, and consumer preference for conventional vehicles.

EV penetration in Indonesia began to be more visible in the early 2010s, when models such as the Nissan Leaf were first shown at national motor shows (Nissan, 2021), although mass-market sales and adoption remained very limited for several years (Wicaksono & Aprianingsih, 2021). A significant turning point occurred in 2019 when the Indonesian government issued Presidential Regulation (Perpres) No. 55/2019 concerning the acceleration of battery-based electric motor vehicles for road transportation. This regulation aims to support the development of domestic electric vehicles, reduce dependence on fossil fuels, and mitigate the impacts of climate change (Hakam & Jumayla, 2024).

Indonesia has set ambitious goals to promote the adoption of electric vehicles (EVs) as part of its efforts to reduce carbon emissions and transition toward a sustainable energy future. As part of the country's broader commitment to environmental sustainability and reducing fossil fuel dependency, the government has targeted 100,000 electric vehicles to be sold by 2025, with a primary focus on battery-electric vehicles (BEVs). This initiative is supported by a suite of policy measures, including tax incentives, regulatory frameworks, and significant investments in charging infrastructure (Xinhua, 2025). The government's push to integrate electric mobility into the mainstream automotive sector is seen as a key strategy in addressing the country's long-term energy challenges while promoting greener technologies. Furthermore, Indonesia is positioning itself as a strategic hub for EV

production in Southeast Asia, attracting substantial investments from global automakers like Hyundai, Toyota, and LG, who are setting up local manufacturing facilities to serve the growing domestic and regional market (IESR, 2021) and (PwC, 2025).

By October 2025, Indonesia had already sold approximately 69,000 BEVs, putting the country well on track to meet the 100,000-unit target. In addition to BEVs, the total sales of all electrified vehicles, including plug-in hybrid electric vehicles (PHEVs) and hybrids, had surpassed 120,000 units by the same period, indicating that broader electrification goals are being met (GAIKINDO, 2025). This rapid growth reflects a broader shift in the market, driven by both consumer demand for cleaner transportation options and supportive government policies. Moreover, Indonesia's push for EV adoption aligns with its broader energy and environmental policy objectives, including the reduction of greenhouse gas emissions and the promotion of renewable energy sources. While the domestic EV market remains in its early stages compared to other global leaders like China and Europe, the country's progress suggests that Indonesia could play a key role in Southeast Asia's growing electric mobility landscape (Manto, 2025).

Despite the growing popularity of electric vehicles in Indonesia and increasingly supportive government policies, EV adoption in the country by 2025 still faces several significant challenges. One example obstacle is the high price of electric cars. Electric vehicles are generally more expensive than internal combustion engine (ICE) vehicles, primarily due to the high cost of battery production. Despite tax incentives and subsidies (Cahyadi & Tjhin, 2025). Limited charging infrastructure is also an obstacle. Although charging stations have begun to be built in several major cities, the uneven distribution of the charging network across Indonesia makes using electric vehicles impractical. This raises concerns about range anxiety, the fear of running out of power outside the city or while traveling long distances (Lazuardy et al., 2024).

Furthermore, public perception of electric vehicles is also a limiting factor. Many consumers remain skeptical about battery life, maintenance costs, and the availability of spare parts for electric vehicles. Furthermore, the perception that electric vehicles don't fully meet daily mobility needs, such as cruising range and performance in difficult road conditions, is a barrier to changing consumer habits (Lazuardy et al., 2024) and also government policies, while supportive of the development of the electric vehicle industry, still face challenges in terms of consistent implementation. Unequal subsidy and incentive

policies across regions, as well as a lack of coordination between government agencies, are obstacles to accelerating the adoption of electric vehicles (Adli Azayaka Huda et al., 2025). On the other hand, Indonesia's macroeconomic conditions, which remain reliant on fossil-fueled vehicles, also influence the adoption rate of electric vehicles. Indonesians tend to choose conventional motorized vehicles due to their affordability and the habits they have developed over the years (Putra Adhiguna, 2023).

And challenges in the electric vehicle supply chain, which have a significant impact on the availability and affordability of EVs in Indonesia. Issues such as high costs and limited supplies of raw materials for EV batteries that are still dominated by China (Danareksa, 2023), inefficient production processes, and inadequate logistics networks. According to (Afifah Humayro, 2024) as a result of these supply chain constraints, it is difficult for manufacturers to build affordable electric vehicles on a wide scale. This further slows the adoption of electric vehicles in the Indonesian market, which still requires aid from other nations such as China, Japan, and South Korea with regard to support.

Given the complexity and interconnection of these elements, it is critical to conduct a systematic analysis and prioritization of the important challenges influencing EV's adoption. The Interpretive Structural Modelling (ISM) approach provides a structured way for identifying and analyzing the interactions between these components (Sudhanshu Ranjan Singh, 2024). The ISM is a highly suitable method for research on electric vehicle adoption in Indonesia. ISM's ability to analyze complex relationships, organize factors in a clear hierarchy, and explore indirect causal relationships provides significant advantages in understanding its dynamics. In this context, ISM enables researchers to develop more targeted and comprehensive data-driven policy recommendations, which are crucial for accelerating electric vehicle adoption in Indonesia (Ab Rahman et al., 2022) and the ISM approach provides valuable insights for stakeholders, including policymakers, manufacturers, and supply chain operators, to address critical obstacles and accelerate Indonesia's transition to electric vehicles.

This study attempts to identify and find the key factors or driving factors influencing the slow adoption of EVs in Indonesia and analyze the relationship between the factors that influence the slow adoption of electric vehicles in Indonesia. Additionally, the purpose of this study is to find the key factors that slow EV adoption in Indonesia, provide ways for

promoting EV adoption in Indonesia by enhancing supply chain efficiency and tackle critical problems. These strategies will help the country shift to sustainable transportation options.

1.2 Problem Formulation

The problem formulation is a clear description of the issue that is required to be resolved or improved through research, in which the problem formulation is a continuation of the problem background. The following are the problem formulations:

- a. What are the key factors or driving factors influencing the slow adoption of EV in Indonesia and what is the relationship between the factors that influence the slow adoption of EV in Indonesia, despite their environmental and economic benefits?
- b. How do challenges in the electric vehicle supply chain, such as raw material procurement, production, logistics, and infrastructure, affect the adoption and availability of electric vehicles in Indonesia?
- c. How can the Interpretive Structural Modeling (ISM) approach be used to analyze and prioritize these factors to provide insights for accelerating electric vehicle adoption in Indonesia?

1.3 Research Objective

The research objective answers the research question:

- a. To identify the key factors or driving factors influencing the slow adoption of EV in Indonesia, and analyze the relationship between the factors that influence the slow adoption of EV in Indonesia, considering both environmental and economic perspectives.
- b. To analyze the challenges in the EV supply chain, including raw material procurement, production processes, logistics, and infrastructure, and their impact on the adoption and availability of electric vehicles in Indonesia.
- c. To apply the Interpretive Structural Modelling (ISM) approach to systematically analyze and prioritize the identified factors, providing a clear framework for understanding their interdependencies and levels of influence.

1.4 Research Benefits

Below are the benefits of the thesis research carried out as follows:

1.4.1 For Researcher

The following are the benefits for researchers:

- a. This research provides insights into the application of methods used in Industrial Engineering, particularly the Interpretive Structural Modeling (ISM) approach, for analyzing and solving real-world challenges in the electric vehicle industry, especially within the context of Indonesia's supply chain.
- b. Researchers can deepen their understanding of how to map the relationships between factors influencing technology adoption decisions, which can be applied to similar research in various fields. This experience also expands skills in data processing and modeling, which can be applied to public policy research and green technology.

1.4.2 For Community

The following are the benefits for the Community:

- a. This research can contribute to increasing public awareness of the importance of adopting electric vehicles as a solution to reduce greenhouse gas emissions and air pollution. A better understanding of the environmental impacts of fossil-fueled vehicles and the potential of electric vehicles in achieving these goals can encourage people to make more environmentally friendly decisions when choosing their mode of transportation.
- b. This research will provide the public with clearer insights into the benefits and challenges of electric vehicle adoption. It will also provide a deeper understanding of factors influencing electric vehicle adoption, such as price, charging infrastructure, government policies, and consumer perceptions.

1.4.3 For Next Research

The following are the benefits for the Community:

- a. This research is expected to be a source of reference or additional information in broadening insight and can be used as a reference for further research related to the adoption of electric vehicle in the future.

1.5 Research Limitation

There are some limitations of the research:

- a. This research focuses on the key factors slowing the adoption of electric vehicles in Indonesia, with a specific analysis of the factor that slow adoption EV's in Indonesia.
- b. The study is limited to Indonesia as the research context, reflecting the unique economic, environmental, and supply chain conditions in the country.

- c. The research utilizes the Interpretive Structural Modelling (ISM) approach to identify and prioritize the interrelationships among influencing factors. Other methodologies, such as quantitative analysis, are beyond the scope of this study.
- d. The analysis is based on secondary data, such as government reports, academic literature, and industry publications, as well as primary data collected through interviews and questionnaires with selected stakeholders.

1.6 Systematic Research

The research is structured into several chapters, and each chapter will be described as follows:

CHAPTER I INTRODUCTION

This section describes the discussion in Chapter I.

CHAPTER II LITERATURE REVIEW

This section describes the discussion that existed in Chapter II.

CHAPTER III RESEARCH METHODOLOGY

This section describes the discussion elaborated in Chapter III.

CHAPTER IV DATA PROCESSING AND RESEARCH RESULTS or SYSTEM DEVELOPMENT

This section describes the discussion in Chapter IV.

CHAPTER V DISCUSSION or SYSTEM TESTING AND DISCUSSION

This section describes the discussion in Chapter V.

CHAPTER VI CONCLUSIONS AND RECOMMENDATIONS

This section draws the conclusion of the study as well as delivers suggestion for future research.

BIBLIOGRAPHY

APPENDIX

CHAPTER II

LITERATURE REVIEW

2.1 Literature Review

The first research is from (Rizaldi, 2024), The thesis focuses on developing a strategy framework for recycling electric vehicle (EV) batteries in Indonesia, including environmental risks and resource waste caused by inappropriate disposal. It underlines the growing importance of sustainable battery recycling techniques as EV use rises and battery waste is expected to reach 332 MWh by 2030. The study's major purpose is to develop a comprehensive strategy for EV battery recycling in Indonesia, supporting the country's pathway to attain Net Zero Emissions (NZE) by 2060 while closing a significant gap in existing recycling activities and legislation. The study used a combination of primary data from expert interviews and questionnaires and secondary data from literature reviews. The Content Validity Index (CVI) and Modified Kappa were used to validate strategy elements, which were then examined using Interpretive Structural Modelling (ISM) to identify linkages and MICMAC analysis to classify strategies based on driving power and reliance. The study identified 20 important strategic factors for EV battery recycling and created a hierarchical structural model to depict their interrelationship. It was shown that only 0.14% of Indonesia's EV supply chain expenditure is committed to recycling. The resulting roadmap emphasizes the importance of developing effective policies and activities to sustainably manage battery trash and promote the country's green energy transition.

Next research was conducted by (Lazuardy, 2024) with the title “Technological, Environmental, Economic, and Regulation Barriers to Electric Vehicle Adoption: Evidence from Indonesia”, focusing on identifying and analysing the barriers to the adoption of electric vehicles (EVs) in Indonesia. These barriers are examined across four key domains: technological, environmental, economic, and regulatory. The study highlights the unique challenges faced by electric car users and electric motorcycle users, aiming to provide insights into the factors that inhibit EV adoption and differentiate between the needs of these two consumer groups. By exploring these barriers, the research seeks to understand why the market penetration of EVs in Indonesia remains significantly low despite ongoing governmental initiatives. The primary purpose of the study is to investigate why EV adoption rates in Indonesia are still low, even though government policies, such as Presidential Regulation 55 of 2019, aim to promote EV use and mitigate air pollution. The research

intends to provide concrete ideas for manufacturers, policymakers, and other stakeholders to overcome the identified barriers. The study adopts a descriptive methodology that incorporates both qualitative and quantitative methods. Data were gathered through surveys issued to 68 electric car users and 407 electric motorcycle users in Jakarta. Respondents assessed 18 factors influencing EV adoption, which were classified into economic, environmental, regulatory, and technological dimensions. Data was collected both online and offline, with random sampling to ensure response variety. Weighted and average values were computed for each factor, and the Mann-Whitney test was used to statistically compare attitudes of electric vehicle and motorbike users. The study identified three important hurdles to EV adoption in Indonesia. Technologically, limited charging infrastructure, battery range limits, and long charging periods were recognized as important problems, with electric car users being more aware of modern technology than motorcycle users. Economically, high initial purchase costs and insufficient financial incentives were seen as major barriers, while electric motorcycles were thought to be more cost-effective than cars. Environmentally, electric car users prioritized conservation and emission reduction, whereas motorcycle users prioritized price and practicality. Regulatory constraints included a lack of suitable public charging stations and minimal government subsidies, with present rules considered as having a greater influence on motorbikes than vehicles.

Referring to “Looking for Key Factors that Can Increase Electric Vehicle Adoption Intentions in Indonesia” by (Muhammad Ifaldhi Hafiz, 2024) focuses on identifying key factors that influence electric vehicle (EV) adoption intentions in Indonesia. It emphasizes the roles of perceived ease of use, environmental concern, and perceived usefulness as significant drivers. Additionally, the study examines attitude as a mediating variable and financial incentive policy as a moderating variable. The purpose of the study is to explore how perceptions and external factors influence Indonesians' intentions to adopt EVs. It aims to provide insights for manufacturers, marketers, policymakers, and stakeholders to design effective strategies that encourage EV adoption. The ultimate goal is to contribute to environmental sustainability by promoting the transition to eco-friendly vehicles. The study uses a quantitative approach, surveying 220 respondents from Indonesia's metropolitan areas through purposive sampling. Data was collected using an online questionnaire with a 5-point Likert scale. The responses were analyzed using Structural Equation Modelling (SEM) with AMOS 26 software to test direct, indirect, and moderating effects of the variables. The study

revealed several key insights into EV adoption intentions in Indonesia. Environmental concern and attitude were found to have a direct and significant impact on adoption intentions, highlighting the importance of eco-consciousness and positive perceptions in driving interest. Perceived ease of use and perceived usefulness, while not directly influencing adoption, shaped attitudes that indirectly impacted the intention to adopt EVs. Furthermore, financial incentive policies played a crucial role in moderating the relationship between attitudes and adoption intentions, demonstrating the importance of government support in encouraging EV uptake.

Next research from (Alfarizi, 2024) with the title “The Transition to Electric Vehicle for the Sustainable Future of the Jakarta Metropolitan Area”. The research analyzes the psychological and social factors influencing the adoption of electric vehicles (EVs) in the Jakarta Metropolitan Area. It highlights the importance of knowledge about EVs, environmental concerns, subjective norms, attitudes, and perceived behavioral control in shaping adoption intentions. Furthermore, the study evaluates how these factors contribute to achieving Sustainable Development Goals (SDGs), particularly in promoting sustainable urban transportation and reducing environmental challenges. The major goal of this study is to better understand the factors that influence behavioral intentions to migrate from conventional to electric automobiles. The study's focus on the psychological and social factors of EV adoption aims to give policymakers and stakeholders useful insights. These insights aim to solve environmental concerns in Jakarta, promote the adoption of sustainable urban transportation solutions, and contribute to the region's overall sustainable development strategy. The study uses a quantitative survey approach to collect data from 200 participants in the Jakarta Metropolitan Area. The study uses purposive sampling to ensure that respondents meet particular criteria, such as age, driver's license ownership, and income level. Data was gathered using online questionnaires and analyzed using Partial Least Squares-Structural Equation Modelling (PLS-SEM). This method assesses the links between key variables, such as EV knowledge, attitudes, subjective norms, perceived behavioral control, and their impact on adoption intentions. The study highlights several important discoveries. First, understanding about electric vehicles and environmental awareness have a substantial impact on subjective norms, attitudes, and perceived behavioral control, which promotes positive perceptions and social norms around EV adoption. Second, positive subjective norms and attitudes play an important role in increasing the inclination to

transition to electric automobiles. Third, a strong sense of behavioral control, such as confidence in utilizing EVs and overcoming obstacles like charging infrastructure, boosts adoption prospects. Finally, embracing electric vehicles helps to achieve the Sustainable Development Goals (SDGs), which include lowering greenhouse gas emissions, improving air quality, and encouraging the use of renewable energy.

The next research from (Ilham Pambudi, 2023) “Electric Vehicles in Indonesia: Public Policy, Impact, and Challenges” this research focuses on analyzing public policies, benefits, and issues associated with the introduction of electric vehicles (EVs) in Indonesia. It focuses on the policy framework, including laws and incentives, and their role in tackling environmental issues, lowering dependency on fossil fuels, and boosting energy efficiency. The study also looks at the impact of these policies on infrastructure, societal adaptation, and sustainable development. The study aims to assess the efficacy of government measures in encouraging EV adoption in Indonesia. It aims to comprehend the economic, environmental, and social consequences of these policies, as well as identify the obstacles and gaps in their implementation. The purpose is to offer measures that would increase the use of battery-powered electric vehicles while remaining aligned with the country's sustainable development and energy transition goals. The study adopts a literature review methodology, evaluating academic publications, government records, and statistical data to gain a thorough grasp of the subject. The paper methodically analyzes earlier research findings to assess the existing policy landscape, its consequences, and the broader obstacles of implementing EV efforts in Indonesia. The findings emphasize Indonesia's attempts to encourage EV adoption through regulations such as Presidential Regulation No. 55 of 2019, which focuses on infrastructure, tax incentives, and local components. EVs can considerably reduce emissions and improve energy efficiency, helping the country achieve its climate goals. However, obstacles such as high pricing, limited charging infrastructure, and little consumer awareness remain. The report underlines the importance of improved incentives, information campaigns, and private sector partnerships to achieve long-term adoption, drawing on worldwide precedents such as California and Japan.

Table 2. 1 Research Gap

Researchers & Years	EV	EV's Adoption	Factors Analysis	Supply Chain	CVI	ISM
Rizaldi (2024)	√	-	-	√	√	√
Lazuardy (2024)	√	√	√	-	-	-
Muhammad Ifaldhi Hafiz (2024)	√	√	-	-	-	√
Alfarizi (2024)	√	√	-	-	-	-
Ilham Pambudi (2023)	√	√	-	-	-	-
Kumar (2023)	√	√	-	-	-	-
Chakraborty (2024)	√	-	-	-	-	-
David S. Rapson (2023)	√	√	-	-	-	-
Candra (2022)	√	√	√	√	-	√
Mcculloch et al. (2024)	√	√	-	√	-	√
Putri et al. (2021)	√	-	√	√	-	-
Lemadi (2022)	√	-	√	√	-	-
Ab Rahman et al. (2022)	-	-	-	-	-	√
Roebianto et al. (2023)	-	-	-	-	√	-

Current research (2025)	√	√	√	√	√	√
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2.2 Theoretical Basis

2.2.1 Diffusion of Innovation (DOI)

Diffusion of Innovation (DOI) theory, developed by Everett Rogers in 1962, provides a framework for understanding how innovations (García-Avilés, 2020) are adopted over time.

DOI identifies five key factors that influence adoption:

a. Relative Advantage

While EVs offer significant long-term benefits, such as fuel savings and environmental friendliness, they are still perceived as more expensive compared to traditional gasoline-powered vehicles. Many Indonesian consumers find it difficult to justify the initial high cost of EVs despite the long-term savings in fuel and maintenance (Farajnezhad et al., 2024).

In the logic of DOI, this means that the perceived relative advantage of EVs is not yet strong enough to trigger mass adoption. Consumers place greater weight on tangible initial costs than perceived long-term savings. Furthermore, environmental benefits (reduced CO₂, cleaner air) are often viewed as public goods that are not directly felt at the individual level, making them insufficient drivers of purchasing decisions (Xiuhong He & Yingying Hu, 2021). The relative advantage is also distorted by subsidized fuel policies and the easy availability of gas stations, so that the “convenience of the status quo” makes the advantages of EVs seem less attractive than conventional vehicles (Li, 2025). Within the ISM framework, this factor can be placed as a proximal factor that is influenced by other factors such as pricing policies, tax incentives, and supply chain cost structures.

b. Compatibility

EVs are not fully compatible with the existing infrastructure in many parts of Indonesia. Charging stations are sparse, especially in rural areas, making the use of EVs impractical for a large portion of the population. Additionally, the lack of public awareness regarding EV technology, including charging mechanisms

and battery life, makes them appear incompatible with the daily mobility needs of Indonesian consumers (Damanik et al., 2025).

Beyond physical infrastructure, compatibility also touches on the cultural aspects of mobility. In many regions, people are accustomed to fossil-fueled vehicles that can be filled up anytime, anywhere, including through retail gasoline vendors (Singh et al., 2024). This gap between users' "how they live" and new technologies' "how they work" explains why, according to the DOI, adoption rates remain low despite policy support (Faiz et al., 2024). In the ISM model, this compatibility tends to emerge as an intermediary factor that bridges macro policies (infrastructure, regulations) with adoption behavior at the individual level.

c. Complexity

For many potential adopters, the maintenance and operation of EVs appear more complex than conventional vehicles. Consumers are concerned about the reliability of EVs, particularly in terms of battery life and charging difficulties. This perception of complexity significantly slows adoption (Mulcahy et al., 2025).

This perception of complexity is often not due to the inherent difficulty of EV technology, but rather to a lack of clear and reliable information. Concerns about battery degradation, replacement costs, safety during rain or floods, and the issue of "what if I break down on the road?" make EVs seem risky and complicated (Fride Vullum-Bruer et al., 2024). The DOI confirms that the higher the perceived complexity, the slower the rate of innovation diffusion. Therefore, complexity here is not only a technical characteristic of EVs, but also a result of information asymmetry and a lack of direct experience. Within the ISM structure (Tsoggerel et al., 2025), complexity is often influenced by other factors such as public awareness, the quality of manufacturer/government education, and the availability of after-sales services.

d. Trialability

The opportunity for trial use of EVs, such as through test drives or rental programs, is limited in Indonesia. Consumers are often unwilling to purchase an EV without experiencing it first hand, leading to hesitation to adopt (Rofi'ah &

Pranajaya, 2025). Low trialability makes it difficult for consumers to move EVs from the "interesting idea" category to the "real choice." Without the opportunity to try them, (Palinkas et al., 2025) says, for example through test-drive programs, car sharing, or short-term rentals, the psychological risk is high because car purchase decisions are high-involvement and long-term. Low trialability also hampers the correction of misconceptions: many concerns (e.g., acceleration performance, ride comfort, or ease of operation) can actually be answered with just one hands-on experience. In ISM, increasing trialability can be modeled as a leverage factor that decreases complexity and increases perceived usefulness simultaneously.

e. **Observability**

The benefits of EV adoption, such as environmental improvement and cost savings, are not highly visible in Indonesia. The limited number of EVs on the road and the lack of widespread adoption makes it harder for consumers to observe these benefits in their daily lives (Sasongko et al., 2024).

Low observability means most people lack role models or real-life examples in their immediate environment. They rarely see neighbors, coworkers, or family members using EVs and sharing positive experiences like lower travel costs or quieter driving (Katherine Dannemiller et al., 2021). Without visible outcomes, the social proof mechanisms that typically accelerate innovation adoption are weakened. Without visible outcomes, the social proof mechanisms that typically accelerate innovation adoption are weakened. Government campaigns and manufacturer advertising cannot fully replace the powerful effects of direct observation in everyday life (Yousef et al., 2021). Within the ISM framework, observability can be positioned as a factor that amplifies the impact of other factors. For example, when infrastructure improves and prices become more affordable, observability will accelerate the spread of information and trust.

2.3 Current Condition in Indonesia

2.3.1 Electric Vehicle

An electric car, often known as a battery electric vehicle (BEV), is a type of vehicle powered by electric motors that use energy stored in rechargeable battery packs. Unlike typical internal combustion engine vehicles, electric vehicles do not use gasoline or diesel fuel for

propulsion. Instead, they use power, which can be obtained from the grid and stored on board batteries.

Electric vehicles have various advantages over traditional vehicles, such as increased energy efficiency, decreased greenhouse gas emissions, and lower running costs. They are also quieter and give a more comfortable driving experience thanks to the quick torque delivery of electric motors. However, limitations in driving range, longer refueling periods, and the requirement for substantial charging infrastructure continue to impede wider use.

Electric vehicles are an excellent way to reduce gas emissions and decrease reliance on oil for transportation. Electricity, rather than traditional fuels such as gasoline or diesel, is used as the primary source of energy to replenish EV batteries. The charging infrastructure is considered a critical component of EV technology, with recent research concentrating on its development to accommodate the increasing number of EVs on the road (Kumar, 2023).

According to (Chakraborty, 2024) Electric vehicles have evolved significantly since their inception as experimental versions. They have evolved into a viable choice in the global automobile market, with important areas of study including breakthroughs in battery technology, market upheavals, and future possibilities. The initial stages of electric propulsion have progressed into the development of more efficient and sustainable transportation alternatives.

2.3.2 EV's Adoption

According to (Zaino, 2024) and (David S. Rapson, 2023). Global adoption of electric cars (EVs) is fueled by technological breakthroughs, environmental benefits, economic considerations, charging infrastructure, supportive policies, and social awareness. Innovations in battery technology and energy storage technologies have considerably improved EV performance, solving problems like range anxiety and allowing a more practical user experience. Government subsidies, tax incentives, and supportive policies have made EVs more financially appealing to consumers, while environmental benefits, like as lower greenhouse gas emissions, coincide with global sustainability goals (Lee, 2021)

However, considerable impediments remain, including the high initial prices of EVs compared to traditional vehicles, limited availability of charging infrastructure, and gaps in public understanding of the long-term benefits of EVs (Harshad Sonar, 2023). In Indonesia, adoption of EVs is hampered by a shortage of charging networks, high import taxes on EV components, and a scarcity of locally built EVs, all of which raise costs. Public awareness

and adoption of EV technology remain low (Candra, 2022), with many consumers considering EVs as luxury items rather than practical alternatives to traditional cars. To make electric vehicles more accessible and desirable, specific policy reforms, investments in charging infrastructure, public education campaigns, and incentives for local production will be required. These initiatives are necessary to support a sustainable transition to electric mobility in Indonesia and elsewhere (Jung F, 2023).

2.3.3 Problem

In Indonesia, adoption of EVs is hampered by a shortage of charging networks, high import taxes on EV components, and a scarcity of locally built EVs, all of which raise costs. Public awareness and adoption of EV technology remain low (Candra, 2022) and about battery life, maintenance costs, and the availability of spare parts for electric vehicles. Furthermore, the perception that electric vehicles don't fully meet daily mobility needs, such as cruising range and performance in difficult road conditions, with many consumers to consider EVs as luxury items rather than practical alternatives to traditional cars. To make electric vehicles more accessible and desirable, specific policy reforms, investments in charging infrastructure, public education campaigns, and incentives for local production will be required. These initiatives are necessary to support a sustainable transition to electric mobility in Indonesia and elsewhere (Jung F, 2023).

2.3.4 Barriers

The adoption of electric vehicles (EVs) in Indonesia faces several significant barriers, many of which continue to impede progress despite ongoing efforts to address them. These barriers include:

a. High Upfront Cost

While subsidies and tax incentives have been introduced, the high cost of EVs remains a major deterrent for the average Indonesian consumer. Many still perceive EVs as unaffordable due to their initial purchase price, which is much higher than that of traditional gasoline vehicles. Despite some efforts to lower prices through government incentives, affordability continues to be a significant barrier for broader adoption. This challenge is particularly pronounced in Indonesia, where GDP per capita is still US\$5,070, meaning most households are highly price-sensitive when purchasing big-ticket items like cars (Focus Economic, 2025).



Figure 2. 1 Indonesia GDP

Most mass-market buyers target vehicles priced under IDR 300 million, yet many batteries electric cars, even the newer “affordable” models, remain in the IDR 300–400 million range or higher, keeping them out of reach for much of the middle class (Adi Putra, 2025).

The government has attempted to narrow this gap through measures such as VAT reductions from 11% to 1% for qualifying EVs, the removal of luxury tax (PPnBM) on certain models, and temporary import duty waivers (PwC Indonesia, 2024). However, these policies have not yet been sufficient to fully align EV prices with comparable internal combustion engine (ICE) vehicles at the showroom level. At the same time, access to attractive financing for EVs, such as lower interest “green” loans, longer tenors, or reduced down payment requirements, remains limited, so the monthly instalments for EVs are still significantly higher than for ICE cars in the same size segment. Studies show that although the total cost of ownership of EVs in Indonesia can be lower than ICE vehicles over the vehicle’s lifetime, thanks to cheaper fuel (electricity) and lower maintenance costs, most consumers continue to focus on the upfront sticker price and the perceived financial risk, including uncertain resale value for relatively new EV brands and models (Kurniawati Hasjanah, 2024). In addition, the price of many EVs is still influenced by imported components, especially batteries, and domestic value-chain development is ongoing rather than fully mature (Putera et al., 2025). As a result, even with current incentives, the high initial purchase cost remains one of the most critical structural obstacles to accelerating EV adoption in Indonesia.

b. Limited EV Charge

The lack of charging stations, especially in rural areas, contributes to range anxiety among consumers. While some urban centers have seen improvements in charging availability, the country's vast geography and infrastructure challenges make it difficult to implement a nationwide network of charging stations. This lack of infrastructure limits the practical use of EVs, especially for long-distance travel.

In Indonesia, this issue is structural rather than merely temporary. Although the number of public charging points has grown rapidly, the network is still very small relative to the size of the country and its vehicle fleet. By the first half of 2024, Indonesia had around 1,582 public fast/normal charging stations (SPKLU), 2,182 public battery-swapping stations (SPBKLU), 9,956 public outlets (SPLU), and roughly 14,500 home chargers. By the end of 2024 this had increased to 3,233 SPKLU, and by late 2025 PLN reported servicing about 4,377 SPKLU nationwide, strong growth, but still far from what is needed for mass-market adoption (Nabilah Muhamad, 2024) and (Rachman Primadya, 2025).

PKLUs have now reached all regions of the country. As of mid-2025, Java still leads with roughly 2,667 units on the island, reflecting the high urban demand. However, Sumatra now hosts over 400 charging points, many placed strategically along highways and rest areas for inter-city travel. Other islands are catching up: Kalimantan has over 200 units, Sulawesi nearly 150, and Bali-Nusa Tenggara-Maluku-Papua collectively around 170 units (Ghebyon Tohada Nainggolan, 2025). When compared with conventional fuel infrastructure, the gap becomes even clearer. Indonesia has roughly 16,000 gasoline stations (SPBU), meaning public EV chargers are outnumbered by fuel stations by almost an order of magnitude (Nabilah Muhamad, 2025). Drivers are accustomed to finding petrol almost everywhere, while charging points remain relatively rare and often located in malls, office buildings, or PLN offices rather than at traditional refueling locations. For many households, especially those living in dense urban kampung areas or rental housing without dedicated parking, home charging is also not straightforward, further limiting practical EV usage.

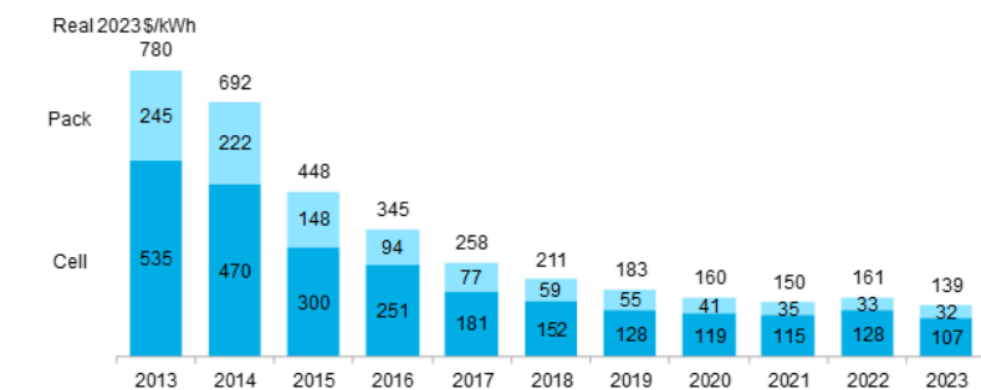
The government has acknowledged this gap and set an ambitious target of around 63,000 SPKLU by 2030, based on a projected EV stock of roughly 940,000 vehicles, implying a planning ratio of about one public charger for every 15 EVs. Independent analyses similarly estimate that tens of thousands of chargers will be required to support passenger EVs alone, suggesting that current deployment is still at an early-stage relative to long-term needs (Ignacio Geordi Oswaldo, 2025). Regulatory and investment frameworks are being revised to accelerate rollout, such as allowing private players to build and operate SPKLU and attracting large investors like VinFast that plan tens of thousands of charging points, but these initiatives will take time to translate into a dense, nationwide network that can substantially reduce range anxiety for Indonesian consumers.

c. Availability and Battery Cost

The cost and availability of batteries remain a critical issue. Batteries are one of the most expensive components of EVs, and the supply chain for critical raw materials such as lithium and cobalt is still vulnerable to price fluctuations and shortages. These challenges contribute to the overall cost of EVs and pose long-term risks to the sustainability of the market.

In Indonesia, this challenge is particularly visible at the vehicle price level. The Ministry of Industry has noted that batteries can account for around 40–50% of an EV's total cost; consequently, any volatility in battery prices is transmitted directly into higher retail prices for consumers (ANTARA, 2024). Even though global lithium-ion pack prices have fallen sharply in recent years, reaching around USD 139/kWh in 2023 and dropping further to roughly USD 115/kWh in 2024 according to BloombergNEF, batteries still represent a large share of the bill of materials for mass-market EVs, especially in emerging markets with thinner purchasing power (BloombergNEF, 2023).

Figure 1: Volume-weighted average lithium-ion battery pack and cell price split, 2013-2023



Source: BloombergNEF. Historical prices have been updated to reflect real 2023 dollars. Weighted average survey value includes 303 data points from passenger cars, buses, commercial vehicles, and stationary storage.

Figure 2. 2 Battery Price

Indonesia's industrial strategy is built around its strength in nickel and other battery metals, but this does not fully resolve cost and availability risks. The country holds the world's largest nickel reserves and has banned exports of raw nickel ore to force more value-added processing and attract investments in smelters and battery plants, with the ambition of becoming a top three global EV battery producer by around 2027 (Isabelle Huber, 2022). However, nickel price cycles remain volatile, and policy discussions about cutting production to support prices add another layer of uncertainty for downstream players planning long-term investments (Anantha Lakshmi et al., 2025).

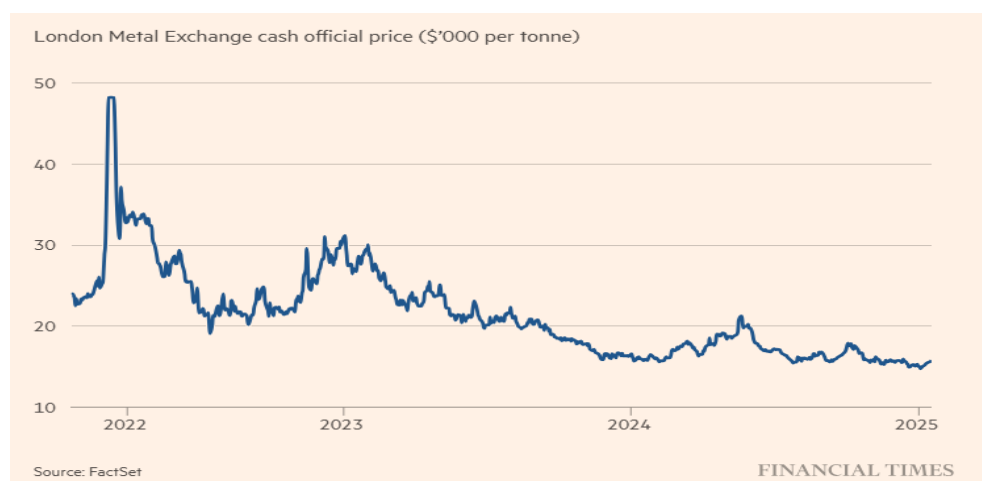


Figure 2. 3 Nickel prices drop on fast-growing Indonesian production

At the same time, Indonesia does not yet have domestic lithium resources at scale, so it depends heavily on imports, primarily from Australia, to produce battery cells. Recent reports indicate Indonesia already imports on the order of 80,000 tons of lithium per year and is preparing to increase that volume to support its EV battery ambitions (Reiner Simanjuntak, 2025). This import dependence exposes the local EV ecosystem to global lithium price swings, foreign exchange risks, and potential trade or geopolitical frictions, all of which can feed into higher or more volatile battery costs for domestic manufacturers and, ultimately, car buyers (Hyundai, 2021). Yet some flagship projects have experienced delays, restructuring, or strategic shifts, highlighting execution risks in scaling a new industry around complex, capital-intensive technology (Putra Adhiguna, 2024). Until these ecosystems mature and achieve economies of scale, Indonesian EV makers will continue to face higher unit battery costs compared with large, more established manufacturing hubs.

From the consumer perspective, battery-related concerns translate into both upfront and long-term cost anxiety. Surveys of Indonesian consumers show that uncertainty about battery lifespan and degradation is one of the top barriers to EV adoption, and that only a small share of current EV users is interested in purchasing a used EV, reflecting fears about the residual value of older batteries and the high potential cost of replacement. Without clear, trusted information on battery durability, transparent warranties, and affordable replacement or second-life options, batteries remain a perceived “cost wildcard,” reinforcing the notion that EVs are financially risky and less accessible for the average Indonesian household.

d. Perception and Consumer Awareness

Many Indonesian consumers are still unaware of the benefits of EVs, particularly in terms of environmental impact and long-term cost savings, so awareness is improving but remains shallow and uneven across segments (PwC Indonesia, 2024). Recent survey work shows that although interest in EVs is increasing, many potential buyers still lack clear information about the total cost of ownership, available incentives, and how EVs compare with conventional vehicles in day-to-day use (PwC Indonesia, 2023).

Studies on Indonesian EV adoption also find persistent misconceptions about EV performance, maintenance complexity, battery lifespan, and reliability, which reinforce the perception that EVs are risky or experimental technologies (Astuti & Susanto, 2024). Survey respondents frequently describe EVs as “pricy” and associated with lifestyle/status consumption, indicating that many still see them as premium or luxury goods rather than practical, everyday mobility solutions (PwC Indonesia, 2023).

These perception gaps help explain why EV penetration in Indonesia is still relatively low compared to regional peers, with battery-electric vehicles accounting for only a small share of the vehicle fleet and new registrations despite growing policy support. Evidence on Indonesia’s green-economy transition shows that, even among younger and more environmentally conscious consumers, practical concerns such as charging access, resale value, and upfront price often outweigh environmental motivations in actual purchase decisions (Core Indonesia, 2024). Strengthening consumer education on EVs, through clearer communication of total cost of ownership, transparent information on incentives and warranties, and visible real-world use cases, is therefore critical to shifting EVs in Indonesia from aspirational “premium gadgets” to mainstream, cost-effective transport options (PwC Indonesia, 2024).

e. Logistic and Distribution

The distribution of EVs in Indonesia is hindered by logistics challenges and the country’s geographical diversity, as the archipelagic layout creates complex, multimodal supply chains for moving vehicles and components between islands (Knowledge Sourcing Intelligence, 2025). With more than 17,000 islands spread across a vast territory, manufacturers and distributors must coordinate combinations of sea and land transport, increasing delivery times and costs compared with more geographically compact markets (East Ventures, 2021).

The lack of dense EV dealership and after-sales service networks in smaller cities and rural districts creates a barrier to entry for consumers, as studies of Indonesia’s electric three-wheeler market highlight limited after-sales service networks, especially in rural areas, as a key adoption challenge (Sanjna Verma, 2024). Furthermore, the high costs of transporting and distributing goods to

Indonesia's outer islands, where logistics costs in eastern Indonesia are structurally higher than in western Indonesia due to economies of scale, make it difficult to deliver EVs profitably to far-flung markets outside major cities (Given Abi Syifa & Muhammad Tohir, 2025).

Overall logistics costs in Indonesia are among the highest in the region, estimated at around 23–24% of GDP in recent years, which erodes margins for vehicle distributors and pushes up retail prices in regions that are expensive to serve (Yose Rizal Damuri et al., 2024). In practice, some of the new EV dealer chains announced to date are still concentrated in large urban centers; for example, VinFast's 15 newly opened dealer stores are all located in major cities such as Jakarta, Bandung, Yogyakarta, Malang, Sidoarjo, Mojokerto, Surabaya, Bali, Batam, and Makassar (VinFast, 2024).

For consumers living in districts without nearby dealers or workshops, limited after-sales support and the need to travel long distances for servicing reinforce perceptions that EV ownership is risky and inconvenient compared with conventional motorcycles and cars, where after-sales service is far more available (CNA, 2023). Government initiatives to cut national logistics costs, such as the National Logistics Ecosystem (NLE) programme and broader logistics-system reforms aimed at reducing the logistics-cost-to-GDP ratio, are therefore not only macroeconomic priorities but also enablers for extending EV distribution and after-sales networks beyond Java and a handful of main corridors (Arimbhi et al., 2021).

2.4 EV SUPPLY CHAIN

2.4.1 EV SUPPLY CHAIN CHANNEL

The electric vehicle supply chain is a complex network involving various parties involved in the production, distribution, and maintenance of electric vehicles. In Figure 2.1, this network covers the external supply chain of electric vehicle.

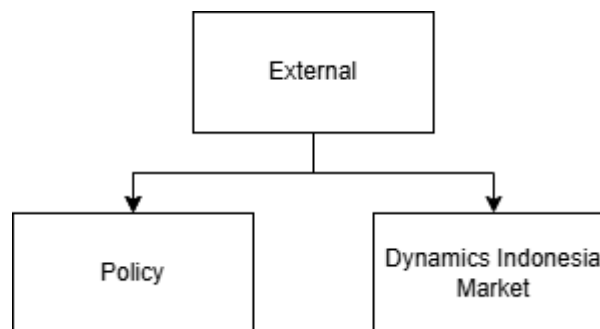


Figure 2. 4 EV Supply Chain Channel

A. Policy

a. TKDN/Local Content

The development of the electric vehicle (EV) industry in Indonesia is closely tied to the government's efforts to increase the Domestic Component Level (TKDN) as a strategy to promote local manufacturing and reduce reliance on imports. According to a study published in the AIP Conference Proceedings, the TKDN for EVs is primarily influenced by components such as batteries (35%), drive trains and power control units (13%), body or frame (7%), and electric instruments (3%) (Henny Sudibyo, 2021). Batteries, in particular, hold the highest value, making their local production critical to achieving higher TKDN. In response, the Indonesian government has collaborated with private manufacturers to develop a national battery industry. Furthermore, to attract investment and accelerate the adoption of EVs, the government revised its TKDN targets, requiring 50% local content for main components between 2020 and 2029, with an increase to 60% by 2030. These initiatives align with Indonesia's broader strategy to build a sustainable domestic EV ecosystem, enhance industrial capabilities, and achieve energy security. By focusing on these targets, the country aims to position itself as a key player in the global EV market.

b. Tax break

Government incentives are crucial in encouraging the use of electric cars (EVs) in Indonesia. Tax deductions, infrastructure availability, and subsidies all have a big impact on EV adoption. Infrastructure and subsidies have a particularly good effect. In the meantime, a study from (Rifelly Dewi Astuti, 2024) highlights how important public involvement, perceived hazards, and simplicity of use are in

determining customer intentions. These results imply that although tax breaks and other financial incentives are necessary, their efficacy can be increased by implementing complete policies, building strong infrastructure, and launching public awareness initiatives. In order to ensure a sustainable transition to electric mobility in Indonesia and to accelerate EV adoption, this combination is essential.

B. Dynamics Indonesia Market

1. User adoption EV

According to (Mcculloch et al., 2024) the market has grown rapidly from a few thousand EVs in 2020 to over 100,000 EVs in 2023, with over a fifth of them being four-wheel drive vehicles. Another research said that with 78% of consumers saying they plan to purchase an EV over the next five years, the Indonesian EV industry is expected to grow quickly. Just 7% of people currently possess an EV, while 15% remain skeptics. But this goal is accompanied by certain demands and inclinations about the kind, cost, and features of the vehicle. With 31% planning to purchase an EV within a year, 62% within two years, and 84% within five years (PwC Indonesia, 2023).

	EV owners	EV prospects	EV sceptics
What is your age? (in average)	42 years	40 years	41 years
What is your gender? (majority of gender)	60% female	51% female	55% male
Where do you live? (majority of response)	85% large city	61% large city	37% suburbs city
Do you commute with a car? (% of yes)	93%	70%	51%
How many km do you commute daily? (in average)	31 km	23 km	23 km

Figure 2. 5 Demographic Users

Based on demographics and commuter patterns, EV owners, potential customers, and doubters are depicted in Figure 2.5. The average EV user is 42 years old, lives in a big city (85%), relies heavily on a car for commuting (93%), is female (60%), and travels 31 kilometers a day on average. EV prospects are somewhat younger (40 years old), female (51%), primarily urban (61%), somewhat dependent on cars (70%), and commute about 23 kilometers every day. In contrast, EV skeptics are more likely to be men (55%), live in a suburb (37%), be less dependent on cars (51%), and commute shorter distances (on average, 23 km). According to the statistics, skeptics are typically suburbanites who are less exposed to EV-friendly environments, whereas urban, car-dependent people with lengthier commutes are more likely to embrace EVs.

2. Market share

Indonesia generated 760,000 tons of nickel. It holds 21 million metric tons of reserves of this mineral. Additionally, it possesses the second-largest copper deposit in the sector and significant reserves of other minerals that are essential for EV production, such as cobalt. The Indonesian government recognizes this advantage and is utilizing it to attract investors to the U.S. EV market (Shree et al., 2024). The Indonesian Government is collaborating with international firms that emphasize sustainability to achieve the nation's Sustainable Development Goals established in alignment with the United Nations, aiming to become an environmentally friendly country and reduce emissions. By 2030, the electric vehicle market in Indonesia is forecasted to exceed US\$20 billion, and the shift of consumers towards these eco-friendly transport alternatives is a crucial advancement towards fulfilling their objectives (PwC Indonesia, 2024).

As the preferred cathode material for EV applications, nickel is anticipated to play a significant role in lithium nickel cobalt manganese oxide (NMC). With effect from 2020, one of the biggest suppliers of nickel ore worldwide, Indonesia, banned the export of nickel ore. The goal of this audacious step is to stimulate the domestic EV industry and attract global investors to relocate their manufacturing operations to the nation (Pandyaswargo et al., 2021). Figure 2.6 shows how's that Indonesia develop an EV's ecosystem.

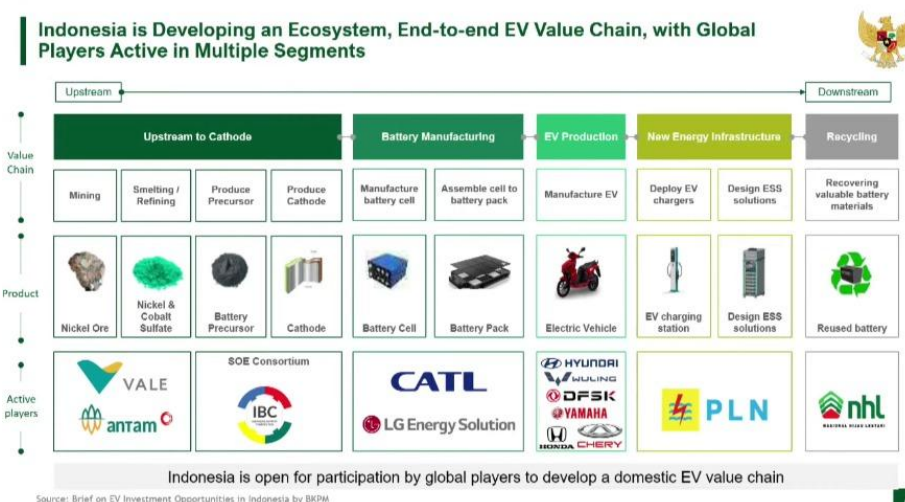


Figure 2. 6 EV Value Chain

A. Upstream to Cathode

According to (Adnan Padhilah Ilham et al., 2023) following the introduction of Presidential Regulation No. 55/2019, Indonesia has successfully developed a supply chain focused on nickel processing for battery manufacturing. This strategy has attracted EV battery producers and suppliers to set up manufacturing facilities within the country. In this stage PT Vale Indonesia Tbk with an average annual nickel production volume reaching 75,000 metric tons. In 2022, the total nickel ore production volume is set at 11.55 million tons, down around 10.28% compared to the previous year's production of 12.88 million tons (Pusnawan & Nainggolan, n.d.) has an important role in the EV supply chain. And there are also Antam and PT Industri Baterai Indonesia participate in the extraction and production of raw materials required for batteries utilized in electric vehicles. In April 2022, a Framework Agreement was signed by the three parties related to industrial chain projects for electric vehicle batteries, which included nickel mining (Arianto Sangadji & Pius Ginting, 2023)

B. Battery Manufacturing

By 2035, Indonesian electric car battery production is projected to account for 12.7% of the global market. It is projected that a value-added analysis method model will result in a \$21,434 billion rise in GDP (Suherman et al., 2021). According to (ACVentures & AEML, 2023) Indonesian government is spending US\$5 billion to construct a battery factory supported by CATL in order to produce cells and battery modules. Additionally, US\$9 billion has been set aside by a partnership headed by

LG Energy, the nation's second-largest EV battery manufacturer, to invest in an integrated battery project that incorporates the local supply chain. These expenditures demonstrate an increasing interest in Indonesia's battery development and manufacturing.

C. EV Production

By 2030, Indonesia wants to have 2 million electric automobiles and 13 million electric motorcycles on the road (Rifqi Khoirul Anam, 2024) and according to (Irawati et al., 2024) among these types of electric vehicles, electric motorcycles are the most widely adopted by the Indonesian people. With companies such as Hyundai, Wuling, DFSK, Yamaha, and Chery as major players in this segment. Hyundai is one of Indonesia's top producers of electric vehicles and is backed by the IK-CEPA deal between South Korea and Indonesia. The Indonesian government works with Hyundai to train technicians and supports the EV sector with incentives. Growing public interest is reflected in the steady increase in sales of cars such as the Hyundai Kona EV, Hyundai Ioniq EV, and Lexus UX300e between 2020 and October 2023 (Ardiyanti et al., 2023).

According to (Kurniawati et al., 2023) Wuling Motors is still superior to its rivals. Not only does Wuling Motors continue to produce innovative products, but it also keeps growing its branch network by opening new locations across Indonesia. 180 Wuling automobiles were sold in 2018. 2019 saw a 2.67% increase in sales, reaching 187 units. Sales rose by 327 units in 2021 after increasing by 300 units in 2020.

(Putra Adhiguna, 2023b) said five to six million motorcycles are sold annually in Indonesia, making it one of the world's biggest motorbike marketplaces. By 2021, there were more than 121 million motorcycles registered nationwide, with Java Island, where most people live, holding close to 60% of the market. Nearly 20,000 electric two-wheelers (E2Ws) were registered as of July 2022, which is a considerable amount of distance from the 13 million the government had set as its 2030 target. With about 96% of the market, Honda and Yamaha are the market leaders in Indonesia.

D. New Energy Infrastructure

Increased adoption of the electric vehicle (EV) needs the proper charging infrastructure integrated with suitable energy management schemes (Bhatti et al.,

2024). The Regulation of the Minister of Energy and Mineral Resources Number 1 of 2023, which regulates the provision of electric charging infrastructure for battery-powered electric motor vehicles, specifies the two primary types of battery charging infrastructure available for electric vehicles in Indonesia: SPKLU (Public Electric Vehicle Charging Stations) that use the Conductive Charging method and SPBKLU (Battery Exchange Stations) that use the Battery Exchange method (Minister of ESDM, 2023) According to (Anshori & Saputro, 2024), significant infrastructure investments are required, especially in electric vehicle charging stations, to help Indonesia reach its 2030 target of 2.45 million electric two-wheelers and 600,000 electric cars. According to the State Electricity Company (PLN) and the Research Director Foundry, Indonesia had 700 SPBKLU and 846 SPKLU as of September 2023. In contrast, there were around 81,525 electric vehicle owners nationwide. Among these were 320 electric three-wheelers, 18,300 electric automobiles, 80 electric buses, 10 electric freight vehicles, and 62,815 electric motorbikes (Hanun et al., 2023).

E. Recycling

According to (Danur Winda & Ardi, 2023) since batteries cost around 40% as much as electric cars (EVs), the Indonesian government is still implementing a scheme to accelerate EVs using batteries. Since EV batteries have an 8–10 year lifespan, they will eventually reach the retirement stage and contribute to environmental waste in the form of underutilized battery waste. Indonesia is expected to have 2 million EVs by 2030, which means that 0.718 million tons of batteries will need to be recycled by 2040. At the recycling stage, there is PT Indonesia Puqing Recycling Technology in Morowali and PT Nasional Hijau Lestari (NHL) (Daily Economic and Market|Review, 2024).

2.5 Expert Determination for the ISM method

The method used in this study is ISM (Interpretative Structural Modelling). According to (Ab Rahman et al., 2022) the fact that most ISM study participants are specialists and not restricted to a single topic makes ISM universal. In this research, Expert judgment in its practical sense is the consideration/opinion of an expert/experienced person (Najwa Karunia Bahar & Wahyu Lestari, 2023).

An elite, peak or high degree of performance on a certain activity or in a particular topic is the generally accepted definition of expertise. When someone reaches this level, they are referred to as an expert or by a similar adjective, such as genius, virtuoso, master, maven, or prodigy (Bourne et al., 2014) .

Experts are essential to research because they provide knowledgeable viewpoints and insights that raise the caliber and legitimacy of investigations, especially in areas with a dearth of or developing empirical evidence. Their knowledge helps create rules, guidelines, and plans based on the most recent and innovative information.

The expert criteria needed for this research are (1) having a minimum of 5 years of experience in the Electric Vehicle sector, power supply company and automotive industry, (2) having a managerial position in a private or non-private company, and (3) having a minimum educational background of a bachelor's degree.

According to (Dumas & Sorce, 1995) five experts are considered enough and (Dworkin, 2012) said an extremely large number of articles, book chapters, and books recommend guidance and suggest anywhere from 5 to 50 participants as adequate. In addition, experts should be representative of all stakeholders of the subject being studied. In best-case practice, experts from academia, industry, and government should be involved in the selection of experts for research so that knowledge is obtained.

2.6 Content Validity

The concept of content validity implies that a measure's validity is partly established by how well its content domains are defined (Fitzpatrick, 1983) and according to (Roebianto et al., 2023) the content validation method involves a readability test to evaluate whether the items or questions accurately represent the variables or constructs being measured, meanwhile (Yaghmalef & Ct, 2003) said content validity measures the factors of interest it is also referred to as content-related validity, intrinsic validity, relevance validity, representative validity, and logical or sample validity. This method assesses the proper sample of questionnaire items based on their content domain.

To validate this content, the CVI (Content Validity Index) method is used, according to (McCoach et al., 2013) the CVI as a way to construct an expert panel item relevancy score. With the exception of the calculated formula and evaluated aspects, the CVI method and the CVR are generally comparable. Relevance and clarity are used in the CVI calculation to

determine content validity, and they are then graded on a 1-4 scale, this 1-4 scale ranges from 1 (not relevant) to 4 (very relevant).

This method's development proceeded, and the CVI was subsequently separated into two categories, scale content validity (S-CVI) and individual item content validity (I-CVI) (Lynn MR, 1984). (Roebianto et al., 2023) give an example, if five of seven experts give a score of 3 or 4 to an item, the I-CVI of the item is $5:7 = 714$ (I-CVI = 714) and (Zamanzadeh et al., 2015) said if an items I-CVI is less than 7 (I-CVI < 70), it should be eliminated, if it is between 70 and 90 ($70 \leq \text{I-CVI} \leq 90$), it should be revised, and if it is greater than 90 (I-CVI > 90), it should be kept.

I-CVI is calculated by determining the proportion of experts who gave a score of 3 or 4 to an item, then dividing it by the total number of experts who rated it. This indicates the level of agreement among experts on the validity of the item (Bianca Amira Rizaldi, 2024). Some studies state the standard criteria for accepting CVI from an instrument that can be seen in the 2.2

Table 2. 2 Expert Interpretation

Total Expert	Minimum I-CVI Value	References
2	$\leq 0,8$	(Davis, 1992)
3-5	1	(Polit & Beck, 2006) and (Polit, Beck, & Steven V. Owen, 2007)
≤ 6	$\leq 0,83$	(Polit & Beck, 2006) and (Polit, Beck, & Steven V. Owen, 2007)
6-8	$\leq 0,83$	(Lynn MR, 1984)
≤ 9	$\leq 0,83$	(Lynn MR, 1984)

The CVI formula is below:

$$I - CVI = \frac{Na}{Ni} \quad (2.1)$$

$$S - CVI = \frac{\sum I - CVI}{Ni} \quad (2.2)$$

Where:

Na = Number of Agreement

Ne = Number of Expert

N_i = Number of Item

Content Validity Index (CVI) is widely used in many studies to estimate validity. This method does not take into account the possibility of increasing values, and the multi-rater kappa method is used to emphasize validity. According to (Mary L McHugh, 2012) the kappa statistic is widely used to assess inter-rater reliability. The significance of rater dependability stems from the fact that it shows the degree to which the data obtained in the study are accurate representations of the variables examined. Interrater reliability is defined as the extent to which data collectors (raters) award the same score to the same variable.

Kappa statistics can be calculated using the formula below:

$$P_c = \left[\frac{N!}{A! (N - A)!} \right] \cdot 5^N \quad (2.3)$$

$$k^* = \frac{I \text{ CVI} - p_c}{1 - P_c} \quad (2.4)$$

Where:

I – CVI = Item Content Validity Index

P_c = Probability of Agreement

N = Total Number of Experts

A = Number of Experts Giving a Score of 3 or 4

Cohen recommended the Kappa finding be understood as follows: Values ≤ 0 indicate no agreement, 0.01-0.20 as none to slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial, and 0.81-1.00 as nearly perfect agreement (Mary L McHugh, 2012). Meanwhile (Polit, Beck, & Steven V. Owen, 2007) to evaluate whether each k^* value is poor (< 0.4), fair (0.40-0.59), good (0.60-0.74), or excellent ($k > 0.74$).

2.6 ISM (Interpretative Structural Modelling)

J. Warfield proposed Interpretive Structural Modelling in 1973 to evaluate complex socioeconomic systems. ISM is a computer-assisted learning approach that allows individuals or groups to create a map of the intricate linkages between the various aspects in a complex scenario. Expert practical expertise and knowledge are used to break down complex systems into sub-systems, resulting in a multi-level structural model (Gorvett & Liu, 2007).

According to (Sianipar, 2012) group decision making serves as the foundation for this approach, which creates a structural model to represent intricate system issues through

meticulously crafted patterns employing phrases and images. Uncertain mental models are converted into observable system models using the ISM approach and ISM has steps which will be explained below.

1. Form a Structural Self Interaction Matrix (SSIM)

According to (Attri et al., 2013) in order to build the contextual relationship among the variables, the ISM approach recommends using expert opinions based on a variety of management methodologies, including brainstorming and nominal group technique, therefore these academic and industry professionals need to be aware of the issue at hand. Contextual relationships that are "leading to" or "affecting" must be chosen in order to assess these elements. This indicates that one element affects another. Contextual linkages between the components that have been found are established based on this.

Therefore (kumar Vikram Singh & Bose Ymcaust Bose Ymcaust, 2019) said Identifying relationships between factors is the process of creating a structural self-interactive matrix (SSIM), which is the result of expert discussions and is shown in a table using the symbols listed below:

- (i,j) - i Represents column of table and j represents rows.
- V - Forward relation (i is related to j)
- A - Reverse relation (j is related to i)
- O - No relation between i and j
- X - Represents reversible relation between i and j .

2. Form an Initial Reachability Matrix (IRM) based on SSIM

In this stage, the IRM is developed from the SSIM that has been formed, according to (kumar Vikram Singh & Bose Ymcaust Bose Ymcaust, 2019) and (Attri et al., 2013) VAXO will be changed to the number 0 or 1, and the following are the provisions for changing the VAXO symbol to a number:

- If element (i,j) is V, then $(i,j) = 1$ and $(j,i) = 0$
- If element (i,j) is A, then $(i,j) = 0$ and $(j,i) = 1$.
- If element (i,j) is X, then $(i,j) = 1$ and $(j,i) = 1$.
- If element (i,j) is O, then $(i,j) = 0$ and $(j,i) = 0$

3. Level Partitioning

At this stage, a hierarchical structure is built between variables. From the FRM, the reachability set, antecedent, and intersection for each variable are derived. The reachability set of a variable includes itself and all variables it influences, while the antecedent set includes itself and all variables it influences. According to (Ahmad & Qahmash, 2021) for the continuation, calculations are performed on the intersection of the reachability set and the antecedent. Variables with the same reachability set and intersection are given the highest rank and then removed for the following iteration and this process continues until all variables are ranked.

4. Conical Matrix (CM) and Digraph

CM is a form of IRM that has been sorted by rows and columns according to the rank or level of the variables that have been determined in the level division stage. The level of each variable is also listed at the end of each row and column in CM. This matrix plays a role in creating a digraph to produce an initial visual representation of the hierarchical structure of the variables. In the digraph, each variable is represented as a circular node with its variable number. Furthermore, these nodes are connected by directed lines according to the value of 1 or 1* in CM for each pair of variables (Ahmad & Qahmash, 2021).

5. Reduced Conical Matrix (RCM) and Final ISM Model

On this step digraph is then converted into a final model by replacing the vertex numbers with variable names and representing the vertices in rectangles. In addition, various efforts are made to reduce the number of edges in the digraph without changing the level, variable structure, or reachability, in order to improve the readability of the final model.

2.7 MICMAC

MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement) is a technique for grouping variables based on their characteristics. In this method, variables are mapped onto a two-dimensional grid based on their dependency and driving force values, which are placed on the horizontal and vertical axes respectively.

These values range from 1 to the total number of variables. Both axes are bisected at the midpoint, forming four quadrants that are numbered counterclockwise. Each quadrant groups variables into four main categories, namely:

1. Autonomous – Variables with low influence and low dependency.

2. Dependent – Variables with low influence but high dependency.
3. Related – Variables with high influence and dependency.
4. Independent – Variables with high influence but low dependency.

This technique helps in understanding the relationship between variables and their role in the system being analysed (Ahmad & Qahmash, 2021).

CHAPTER III

RESEARCH METHOD

3.1 Research Subject

This research was conducted in Indonesia, using references from several institutions and think tanks with expert knowledge in the Indonesian EV industry. The scope of this study includes factors influencing EV adoption in Indonesia.

3.2 Research Object

The object of this study factors that influence and become barriers to EV adoption in Indonesia. In addition, there will be validation tests with CVI and Kappa based on data found from previous studies and later there will be opinions from experts whether these factors are indeed barriers to EV adoption in Indonesia. Therefore, ISM is used to find out whether these factors show a relationship with each other and determine the key factors that make EV adoption in Indonesia slow.

3.3 Data Analysis Method

In this study, the MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement) method was used to analyze data which will later be used to classify variables based on driving power and dependence power.

3.4 Data Collection

The data was obtained from the results of interviews and questionnaire distribution, which later the data will be processed using the ISM (Interpretive Structural Modeling) method and this method will produce a structural model in the form of a structure diagram with levels of participation along with an interpretation of the contextual relationship in each strategy.

3.5 Research Flow

The flow of the research is as follows:

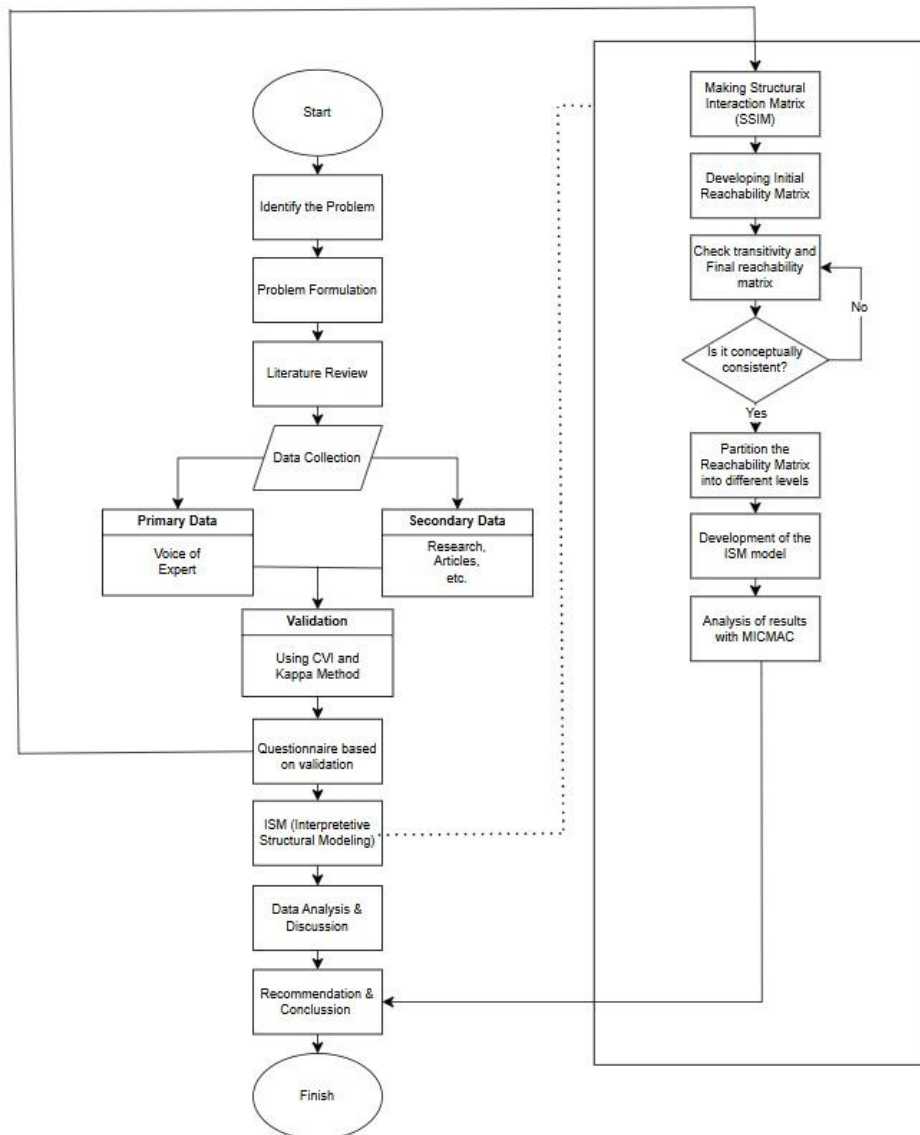


Figure 3. 1 Research Flow

The description of each flow in the flowchart:

1. Start

Where the research was started.

2. Identify the Problem

At this point, there is a problem why the adoption of electric vehicles in Indonesia is considerably slow and how the supply chain constraints of electric vehicles are. After reviewing previous research, several factors or problems were found that hinder the adoption of electric vehicles in Indonesia.

3. Problem Formulation

After identifying the problem, the researcher tried to find ideas on how to solve the problem. Several solutions without support and background came to the researcher's

mind. One of the ideas that was set was to identify whether the factors intersect or not and find the key factors that make the adoption of electric vehicles in Indonesia slow.

4. Literature Review

At this time, researchers require enlightenment to overcome similar challenges. Several research have been undertaken and published on comparable challenges, but one study differs in its purpose, while the others differ in how to solve the problem. Finally, the ISM (Interpretive Structural Modelling) method was used to determine whether or not the components intersected and to identify the key factors.

5. Data Collection

After finding and ensuring the solution to the method, the data needed to conduct research and run the method are two data needed:

a. Primary Data

Validated data and data that will be used for the ISM method

b. Secondary Data

The researcher reviews the problems from previous research, what factors are the problems.

6. Validation

At this stage, the researcher validates the data obtained from previous research and at this stage the researcher asks for the opinions of experts and validates it using the CVI and Kappa methods.

7. Questionnaire Based on Validation

After the data has been validated, the researcher creates a second stage questionnaire which will then be processed using the ISM method.

8. ISM (Interpretive Structural Modelling)

After obtaining data from the questionnaire, the researcher continued processing it using the ISM method, and these are some of the stages:

a. Making Structural Interaction Matrix (SSIM)

At this stage, the data will be processed to develop contextual relationships between elements (i and j) and the direction of the relationship can be described with 4 symbols (V, A X, O)

b. Developing Initial Reachability Matrix

The next stage is to develop the Initial Reachability Matrix from the SSIM that has been formed. The results of the SSIM assessment of 4 symbols, namely VAXO, will be changed into binary numbers (0 or 1). The following are the provisions for changing the VAXO symbol to binary.

c. Check transitivity and Final reachability matrix

After the initial model is built, a transitivity check is performed to confirm the validity of the relationships between the different variables. Transitivity checks are usually performed by analyzing the relationship matrix between the different variables and checking that the relationships are consistent with the logic of the model.

d. Is it conceptually consistent?

Here the researcher checks whether it is correct conceptually or not.

e. Partition the Reachability Matrix into different levels

From the reachability matrix, an initial digraph is obtained that includes transitive links. After removing indirect links, the final digraph is developed to represent elements and their relationships in the form of nodes and edges. The top-level factor is placed at the top, followed by the next levels hierarchically to the bottom level.

f. Development of the ISM model

The development of the ISM model can be done based on the conical shape of the matrix or from the predetermined level partition. Elements that have the same level will be placed parallel in the construction of the ISM diagram model. The ISM diagram is depicted in the form of nodes with arrows indicating the relationship between elements of one strategy and another.

g. Analysis of results with MICMAC

MICMAC analysis measures the driving power and dependence power of factors based on matrix multiplication. The goal is to identify the key factors that drive the system. Based on these two forces, factors are classified into four categories (autonomous factors, linkage factors, dependent factors, and independent factors).

9. Data Analysis & Discussion

At this stage, analyze the overall results (Factors Influencing Electric Vehicle Adoption in Indonesia) and discussing the research results, researchers compare the findings with previous studies to see whether the results obtained support or differ from other studies and understand the causes of the differences.

10. Recommendation & Conclusion

In the recommendations and conclusions stage, researcher do several important things to summarize the research results and provide suggestions that can be implemented by stakeholders.

11. Finish

Where the research was finished.

CHAPTER IV

DATA COLLECTION AND PROCESSING

4.1 Data Collection

The researchers carried out a literature review using various sources, including journals, research papers, and articles, covering a range of topics related to the factors that slowing electric vehicle adoption. From the collected data, they identified 15 categories encompassing 15 Item, which relate to aspects such as economic conditions, infrastructure, cultural preferences, resource availability, manufacturing, logistics, vehicle models, public perception, government policies, and public awareness.

Below are a list of 15 categories and 15 items that will be shown in the Table 4.1.

Table 4. 1 Category and Item

Category 1	Item	Code	Argumentation	Reference
High Vehicle Costs	Financial and economic barriers to electric vehicle adoption.	F1	High initial purchase price is a significant barrier to electric vehicle adoption in Indonesia. Government incentives, such as subsidies or tax breaks, would increase the likelihood that I would purchase an electric vehicle. The long-term cost savings of owning an electric vehicle outweigh the high initial cost.	(Chandra, 2022) (Siti Aprillia et al., 2024) (Astuti & Susanto, 2024b)
Category 2	Item	Code	Argumentation	Reference
Limited Public Awareness	Awareness and knowledge of electric vehicles.	F2	The public is realizing the environmental benefits associated with electric vehicles. There is ample public information available about the advantages of electric vehicles. Educational campaigns can effectively increase public awareness and adoption of electric vehicles.	(Josua Jeffrey Handopo & Elfindah Princes, 2024) (Siti Aprillia et al., 2024) (Daniswara Wahono Putri et al., 2025)
Category 3	Item	Code	Argumentation	Reference

Undeveloped Facilities	Limited Charging Infrastructure	F3	The current availability of charging infrastructure is not sufficient to support the adoption of electric vehicles. The presence of charging stations in an area will influence potential consumers' decisions to purchase electric vehicles. Developing charging infrastructure in rural areas is critical to the widespread adoption of electric vehicles.	(Chandra, 2022) (Septihani Michella Wijaya et al., 2023) (Electric Vehicles in Rural Communities, 2022)
Category 4	Item	Code	Argumentation	Reference
Preference for Conventional Vehicles	Cultural preferences and habits towards conventional vehicles.	F4	Conventional gasoline or diesel fueled vehicles are more reliable than electric vehicles. People prefer conventional vehicles due to concerns about the limited range of electric vehicles. The transition to electric vehicles is being hampered by a lack of confidence in the new technology.	(García Contreras & Cecilia Pamela, 2023) (PwC Indonesia, 2024) (Suyanto & Pasaribu, 2023)
Category 5	Item	Code	Argumentation	Reference
Limited EV Battery Supply	Availability and cost of electric vehicle batteries.	F5	The availability of electric vehicle batteries in Indonesia meets current demand. Concerns about battery life and replacement costs are preventing potential consumers from considering electric vehicles. Developing local battery production will increase the adoption of electric vehicles.	(Faris Adnan Padhilah et al., 2023) (PwC Indonesia, 2024) (Hakam & Jumayla, 2024)
Category 6	Item	Code	Argumentation	Reference

Inefficient Production	Manufacturing and production challenges.	F6	Indonesia's current electric vehicle production capacity is sufficient to meet market demand. There is a shortage of skilled labor and expertise in electric vehicle manufacturing in Indonesia. Increasing production efficiency will reduce the costs of electric vehicles.	(Sasongko et al., 2024) (Mubarok & Kartini, 2023) (Berckmans et al., 2019)
Category 7	Item	Code	Argumentation	Reference
Inadequate Logistics Network	Logistics and distribution barriers for electric vehicles.	F7	The availability of electric vehicles is limited due to the inadequate logistics network in Indonesia. Lack of collaboration between manufacturers and logistics providers hampers efficient distribution of electric vehicles. Improving the logistics network will increase the accessibility and availability of electric vehicles in rural and remote areas.	(Love Sabandar, 2024) (Jagani et al., 2024) (Electric Vehicles in Rural Communities, 2022)
Category 8	Item	Code	Argumentation	Reference
Limited Choice of Electric Vehicle Models	Variety and availability of electric vehicle models on the market.	F8	The electric vehicle models available in Indonesia may not meet people's preferences or needs. Many consumers feel that electric vehicle choices are still limited compared to fossil fuel vehicles. The choice of electric vehicle models available in Indonesia is still too limited.	(Suyanto & Pasaribu, 2023) (Josijević et al., 2022) (Bui et al., 2020)
Category 9	Item	Code	Argumentation	Reference
Lack of Trust in New Technology	Public perception of the reliability, safety and	F9	Some people still doubt the reliability of electric vehicle technology, especially in terms of	(Pamidimukkala et al., 2023)

	durability of electric vehicles.		safety and battery life. There are concerns about maintenance costs and whether electric vehicles can last as long as conventional vehicles. There are concerns that electric vehicles are not as safe as conventional vehicles in terms of safety.	(Cahyadi & Tjhin, 2025) (Macharis et al., 2013)
Category 10	Item	Code	Argumentation	Reference
Unclear Government Regulations and Policies	Certainty and effectiveness of government policies and incentives for electric vehicles.	F10	Some potential buyers are still hesitant because there is no certainty of long-term incentives from the government. Regulations related to taxes, incentives, and supporting infrastructure may still be unclear or not running optimally. Unclear regulations regarding electric vehicles make potential buyers hesitant to switch from conventional vehicles.	(I Putu Gede Suartika, 2023) (ITDP, 2023) (Agung Wibowo Yudha, 2023)
Category 11	Item	Code	Argumentation	Reference
Perception between Urban and Rural Communities	Suitability of electric vehicles to geographical conditions and infrastructure in various regions.	F11	Electric vehicles are more suitable for use in big cities than in rural areas where infrastructure is still minimal. There are concerns that electric vehicles are unreliable for long trips or in areas with unstable electricity access. Electric vehicles are more suitable for use in modern areas.	(Juliaster Marbun et al., 2023) (Kumar et al., 2023) (Bhanuka Samarakoon et al., 2024)
Category 12	Item	Code	Argumentation	Reference
Low public education	The level of public understanding about how electric	F12	Understanding of how electric vehicles work, including charging mechanisms and their daily use, is still limited	(Faris Adnan Padhilah et al., 2023) (Rahman Zaenal Fachri, 2023a)

	vehicles work, charge and maintain them		in the community. Information regarding the maintenance and reliability of electric vehicles is still not widely available. The main differences between electric vehicles and fossil fuel vehicles in terms of efficiency and technology are not widely known by the public.	(Hakam & Jumayla, 2024)
Category 13	Item	Code	Argumentation	Reference
Availability of Skilled Technicians	The level of skilled Technicians in Indonesia didn't same with the other country	F13	The lack of qualified technicians for electric vehicle maintenance and repair could be a barrier to adoption.	(Kumar et al., 2023) (Rahman Zaenal Fachri, 2023) (Arief Nurdini et al., 2024)
Category 14	Item	Code	Argumentation	Reference
Long-Term EV Sustainability Concerns	EVs are still a source of concern and questions regarding long-term use	F14	Even though electric vehicles have been present in the market for over a decade, concerns about their long-term sustainability, including battery life, cost of replacement, and environmental impact of battery disposal, remain significant obstacles.	(Arif Anugraha & Hargo Utomo, 2025) (Josua Jeffrey Handopo & Elfindah Princes, 2024b) (Arief Nurdini et al., 2024)
Category 15	Item	Code	Argumentation	Reference
Inconsistent Government Policies	Government policy is still inconsistent until now.	F15	While the government supports the EV industry, inconsistent policies and uneven implementation of subsidies and incentives across regions slow down the progress. Coordination between government agencies remains a challenge in promoting EV adoption.	(Teuku Naraski Zahari et al., 2022) (Maulana & Kurniawan, 2024) (Yuniza et al., 2021)

4.2 Validation Test

At this stage, the collected data is validated using the Content Validity Index (CVI) method. The purpose of this validation is to evaluate the relevance of each indicator in relation to the research problem. A preliminary questionnaire is developed and distributed to experts, who assess the relevance of each indicator using a 4-point scale: 1 (Not Relevant), 2 (Somewhat Relevant), 3 (Quite Relevant), and 4 (Highly Relevant). According to (Polit, Beck, & Owen, 2007) the recommended number of experts ranges from 3 to 10 in this study, the researcher engaged 5 experts to complete the validation questionnaire.

Table 4. 2 Expert for Validation

No	Expert	Position	Sector	Experience
1	A	Total Industrial Engineering Staff and Leader Production at PT. Denso Manufacturing Indonesia.	OEM Auto parts	7 Years
2	B	Senior Project Manager at Mercedes-Benz Group.	Automobile (Private Vehicle, PHEV)	13 Years
3	C	Director of PT. Mitsubishi Krama Yudha Motors and Manufacturing (MKM)	Automobile (Commercial Vehicle, PHEV)	25 Years
4	D	Automotive Analyst at The German Autopreneur	EV Consultant and Press	5 Years
5	E	Senior Officer Performance	Utilities	10 Years

		Assistant to Manager at PT. PLN		
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4.3 I-CVI Validation Test Data Processing

At the data processing stage, expert opinions are collected through a scale of 1 to 4, then validation data processing is carried out through CVI for each indicator (I-CVI). This validation is based on the number of experts who assess 3 or 4 as valid and 1 and 2 as invalid. With a minimum I-CVI 10 experts is 0.78 to be said to be valid. The results of I-CVI data processing can be seen in Table 4.3.

Table 4. 3 Result of I-CVI

Code	Item	Experts	Agree	I-CVI	CVI Interpretation
F1	Financial and economic barriers to electric vehicle adoption.	5	4	0,80	Excellent
F2	Awareness and knowledge of electric vehicles.	5	3	0,60	Good
F3	Limited Charging Infrastructure	5	5	1,00	Excellent

Code	Item	Experts	Agree	I-CVI	CVI Interpretation
F4	Cultural preferences and habits towards conventional vehicles.	5	5	1,00	Excellent
F5	Availability and cost of electric vehicle batteries.	5	5	1,00	Excellent
F6	Manufacturing and production challenges.	5	3	0,60	Good
F7	Logistics and distribution barriers for electric vehicles.	5	5	1,00	Excellent
F8	Variety and availability of electric vehicle models on the market.	5	0	0,00	Poor

Code	Item	Experts	Agree	I-CVI	CVI Interpretation
F9	Public perception of the reliability, safety and durability of electric vehicles.	5	3	0,60	Good
F10	Certainty and effectiveness of government policies and incentives for electric vehicles.	5	4	0,80	Excellent
F11	Suitability of electric vehicles to geographical conditions and infrastructure in various regions.	5	3	0,60	Good
F12	The level of public understanding about how electric vehicles work, charge and maintain them	5	2	0,40	Fair
F13	The level of skilled Technicians in Indonesia didn't same with the other country	5	2	0,40	Fair
F14	EVs are still a source of concern and questions regarding long-term use	5	5	1,00	Excellent

Code	Item	Experts	Agree	I-CVI	CVI Interpretation
F15	Government policy is still inconsistent until now.	5	5	1,00	Excellent

After obtaining the CVI Interpretation, data processing was carried out using Modified Kappa as a complement to the CVI method.

Table 4. 4 Result of CVI and Kappa

Code	Item	I-CVI	CVI Interpretation	K*	K* Interpretation	Final Interpretation
F1	Financial and economic barriers to electric vehicle adoption.	0,80	Excellent	0,76	Excellent	Both Valid
F2	Awareness and knowledge of electric vehicles.	0,60	Good	0,42	Fair	Both Invalid
F3	Limited Charging Infrastructure	1,00	Excellent	1,00	Excellent	Both Valid

Code	Item	I-CVI	CVI Interpretation	K*	K* Interpretation	Final Interpretation
F4	Cultural preferences and habits towards conventional vehicles.	1,00	Excellent	1,00	Excellent	Both Valid
F5	Availability and cost of electric vehicle batteries.	1,00	Excellent	1,00	Excellent	Both Valid
F6	Manufacturing and production challenges.	0,60	Good	0,42	Fair	Both Invalid
F7	Logistics and distribution barriers for electric vehicles.	1,00	Excellent	1,00	Excellent	Both Valid
F8	Variety and availability of electric vehicle models on the market.	0,00	Poor	-0,03	Remove	Both Invalid

Code	Item	I-CVI	CVI Interpretation	K*	K* Interpretation	Final Interpretation
F9	Public perception of the reliability, safety and durability of electric vehicles.	0,60	Good	0,42	Fair	Both Invalid
F10	Certainty and effectiveness of government policies and incentives for electric vehicles.	0,80	Excellent	0,76	Excellent	Both Valid
F11	Suitability of electric vehicles to geographical conditions and infrastructure in various regions.	0,60	Good	0,42	Fair	Both Invalid
F12	The level of public understanding about how electric vehicles work, charge and maintain them	0,40	Fair	0,13	Poor	Both Invalid
F13	The level of skilled Technicians in Indonesia didn't same with the other country	0,40	Fair	0,13	Poor	Both Invalid

Code	Item	I-CVI	CVI Interpretation	K*	K* Interpretation	Final Interpretation
F14	EVs are still a source of concern and questions regarding long-term use	1,00	Excellent	1,00	Excellent	Both Valid
F15	Government policy is still inconsistent until now.	1,00	Excellent	1,00	Excellent	Both Valid

After being refined with Modified Kappa, the results were obtained on several invalid indicators. It can be seen in code F2 with item " Awareness and knowledge of electric vehicles.", code F6 with item "Manufacturing and production challenges.", code F8 with item "Variety and availability of electric vehicle models on the market.", code F9 with item "Public perception of the reliability, safety and durability of electric vehicles.", F11 with item "Suitability of electric vehicles to geographical conditions and infrastructure in various regions.", F12 "The level of public understanding about how electric vehicles work, charge and maintain them" and F13 with item "The level of skilled Technicians in Indonesia didn't same with the other country".

After code and item have been sorted, the validated indicator is obtained which will later be used as material for the ISM (Interpretive Structural Modelling) method questionnaire which can be seen in the following table:

Table 4. 5 Valid Item

Code	Item
F1	Financial and economic barriers to electric vehicle adoption.
F2	Limited Charging Infrastructure.
F3	Cultural preferences and habits towards conventional vehicles.

Code	Item
F4	Availability and cost of electric vehicle batteries.
F5	Logistics and distribution barriers for electric vehicles.
F6	Certainty and effectiveness of government policies and incentives for electric vehicles.
F7	EVs are still a source of concern and questions regarding long-term use.
F8	Government policy is still inconsistent until now.

4.4 Data processing using ISM (Interpretive Structural Modeling)

At this stage, the data will be explained and reprocessed using the ISM (Interpretive Structural Modelling) method to build a hierarchical model of factors that slow the adoption of electric vehicle in Indonesia. Validated indicator has been obtained using CVI and Modified Kappa and will be continued using the ISM method to form an ISM model from validated indicator. The first step taken is to create a 2nd questionnaire that will be distributed to experts to find contextual relationships in indicators and will later be processed into the SSIM matrix. The questionnaire is carried out with a pairwise system, the formula used to add up the total questions is below:

$$\text{Number of Questions} = \left[(N) \times \frac{(N - 1)}{2} \right] \quad (4.1)$$

The number N is the total number of all validated indicator, which is 8, resulting in 28 questions.

The relationship in each element is the relationship between two sub-elements (i and j), the relationship that leads or influences must be selected, meaning that one factor influences another factor. Assessment of the relationship with indicators or factors is based on four symbols, namely V, A, X and O, with the following description:

- V - Forward relation (i is related to j)
- A - Reverse relation (j is related to i)
- O - No relation between i and j
- X - Represents reversible relation between i and j.

The second questionnaire was distributed to 5 experts with different backgrounds, as can be seen in Table 4.6.

Table 4. 6 Expert for ISM

No	Expert	Position	Sector	Experience
1	A	Total Industrial Engineering Staff and Leader Production at PT. Denso Manufacturing Indonesia	OEM Auto parts	7 Years
2	B	Senior Project Manager at Mercedes-Benz Group	Automobile (Private Vehicle, PHEV)	13 Years
3	C	Director of PT. Mitsubishi Krama Yudha Motors and Manufacturing (MKM)	Automobile (Commercial Vehicle, PHEV)	25 Years
4	D	Automotive Analyst at The German Autopreneur	EV Consultant and Press	5 Years
5	E	Senior Officer Performance Assistant to Manager at PT. PLN	Utilities	10 Years

After distributing the questionnaire to the expert and getting their different opinions to determine the Decision. Experts fill in the answer column using the symbols V, A, X, O and each symbol has a different value, the answer V is translated into $i \rightarrow j$ is valued 1

and $j \rightarrow i$ becomes 0, for the symbol $A \ i \rightarrow j$ is valued 0 and $j \rightarrow i$ becomes 1, for the symbol $X \ i \rightarrow j$ is valued 1 and $j \rightarrow i$ becomes 1 and the last $O \ i \rightarrow j$ is valued 0 and $j \rightarrow i$ becomes 0. The results of data processing can be seen in the Table 4.7 and for the interpretation of the results, why can the symbols V, A, X, O be determined from (Attri et al., 2013) The V, A, X, O symbols are determined by comparing the two directions simultaneously as described above. The percentages used, 20%, 40%, 60%, 80%, and 100%, are simply a descriptive way of reporting the degree of agreement $(k/5) \times 100\%$, the majority decision per pair of directions remains the binding symbol, not a single percentage range assigned to one direction without comparing the opposite direction. This rule is consistent with the ISM methodological guidelines on panel formation of SSIMs and their conversion to IRMs with transitivity checks and to determine the symbolic results, the following rules apply:

- V: Only $i \rightarrow j$ is more than 50% (only i influences j).
- A: Only $j \rightarrow i$ is more than 50% (only j influences i).
- X: Both directions of the relationship are greater than 50% (mutual influence).
- O: Both relationships are less than 50% (no significant relationship).

And here is the complete data that has been obtained:

Table 4. 7 Processing the Data from Expert

No	Code	Expert					1		2		3		4		5		Total		Result
		1	2	3	4	5	$i \rightarrow j$	$j \rightarrow i$	$i \rightarrow j$	$j \rightarrow i$	$i \rightarrow j$	$j \rightarrow i$	$i \rightarrow j$	$j \rightarrow i$	$i \rightarrow j$	$j \rightarrow i$	$i \rightarrow j$	$j \rightarrow i$	
1	F1-F2	V	X	O	X	X	1	0	1	1	0	0	1	1	1	1	80 %	60 %	X
2	F1-F3	A	A	V	X	A	0	1	0	1	1	0	1	1	0	1	40 %	80 %	A
3	F1-F4	A	O	O	X	V	0	1	0	0	0	0	1	1	1	0	40 %	40 %	O
4	F1-F5	V	O	V	X	X	1	0	0	0	1	0	1	1	1	1	80 %	40 %	V
5	F1-F6	O	A	A	X	A	0	0	0	1	0	1	1	1	0	1	20 %	80 %	A
6	F1-F7	A	O	O	X	A	0	1	0	0	0	0	1	1	0	1	20 %	60 %	A
7	F1-F8	A	A	X	X	A	0	1	0	1	1	1	1	1	0	1	40 %	100 %	A
8	F2-F3	A	V	X	X	V	0	1	1	0	1	1	1	1	1	0	80 %	60 %	V
9	F2-F4	A	O	O	O	O	0	1	0	0	0	0	0	0	0	0	0 %	20 %	O
10	F2-F5	O	O	O	X	A	0	0	0	0	0	0	1	1	0	1	20 %	40 %	O
11	F2-F6	A	X	O	X	A	0	1	1	1	0	0	1	1	0	1	40 %	80 %	A
12	F2-F7	A	O	A	X	O	0	1	0	0	0	1	1	1	0	0	20 %	60 %	A
13	F2-F8	A	A	O	X	O	0	1	0	1	0	0	1	1	0	0	20 %	60 %	A
14	F3-F4	O	O	A	O	O	0	0	0	0	0	1	0	0	0	0	0 %	20 %	O
15	F3-F5	O	O	V	X	O	0	0	0	0	1	0	1	1	0	0	40 %	20 %	O

No	Code	Expert					1		2		3		4		5		Total		Result
		1	2	3	4	5	i -> j	j -> i	i -> j	j -> i	i -> j	j -> i	i -> j	j -> i	i -> j	j -> i	i -> j	j -> i	
16	F3-F6	X	V	A	A	A	1	1	1	0	0	1	0	1	0	1	40 %	80 %	A
17	F3-F7	X	V	A	A	V	1	1	1	0	0	1	0	1	1	0	60 %	60 %	X
18	F3-F8	X	A	X	O	A	1	1	0	1	1	1	0	0	0	1	40 %	80 %	A
19	F4-F5	O	X	X	A	A	0	0	1	1	1	1	0	1	0	1	40 %	80 %	A
20	F4-F6	X	X	A	V	A	1	1	1	1	0	1	1	0	0	1	60 %	80 %	X
21	F4-F7	X	A	X	X	V	1	1	0	1	1	1	1	1	1	0	80 %	80 %	X
22	F4-F8	X	V	V	V	A	1	1	1	0	1	0	1	0	0	1	80 %	40 %	V
23	F5-F6	X	X	A	A	A	1	1	1	1	0	1	0	1	0	1	40 %	100 %	A
24	F5-F7	O	O	X	X	V	0	0	0	0	1	1	1	1	1	0	60 %	40 %	V
25	F5-F8	A	A	A	A	A	0	1	0	1	0	1	0	1	0	1	0 %	100%	A
26	F6-F7	V	X	V	X	V	1	0	1	1	1	0	1	1	1	0	100 %	40 %	V
27	F6-F8	V	A	X	A	A	1	0	0	1	1	1	0	1	0	1	40 %	80 %	A
28	F7-F8	X	A	X	A	A	1	1	0	1	1	1	0	1	0	1	40 %	100 %	A

4.4.1 Structural Self-interaction Matrix (SSIM)

After processing the data, the next step is to construct a structural self-interaction matrix (SSIM). The results are presented in an 8 x 8 matrix, as shown below:

Table 4. 8 SSIM Matrix

Code	F1	F2	F3	F4	F5	F6	F7	F8
F1		X	A	O	V	A	A	A
F2			V	O	O	A	A	A
F3				O	O	A	X	A
F4					A	X	X	V
F5						A	V	A
F6							V	A
F7								A
F8								

4.4.2 Initial Reachability Matrix (IRM)

After completing the Structural Self-Interaction Matrix, the next step is to create the Initial Reachability Matrix. At this stage, the symbols will be converted into numerical results. For more details, see the rules below:

Logical consistency when converting to a binary matrix when converted to a reachability matrix:

- $V \rightarrow (i,j) = 1$ and $(j,i) = 0$
- $A \rightarrow (i,j) = 0$ and $(j,i) = 1$

- $X \rightarrow (i,j) = 1$ and $(j,i) = 1$
- $O \rightarrow (i,j) = 0$ and $(j,i) = 0$

This rule ensures that the pairs (i,j) and (j,i) are filled in congruently and “- “will be replaced with 1 because basically in the context of reachability, which means we do not assess this factor and also the technical rules so that reachability and all ISM procedures are consistent and well-defined. The results of the changes can be seen below:

Table 4. 9 IRM Matrix

Code	F1	F2	F3	F4	F5	F6	F7	F8
F1	1	1	0	0	1	0	0	0
F2	1	1	1	0	0	0	0	0
F3	1	0	1	0	0	0	1	0
F4	0	0	0	1	0	1	1	1
F5	0	0	0	1	1	0	1	0
F6	1	1	1	1	1	1	1	0
F7	1	1	1	1	0	0	1	0
F8	1	1	1	0	1	1	1	1

After forming the initial reachability matrix, the next step is to check the transitivity rule, where the basic principle is that if factor A affects factor B and factor B affects factor C, then element A affects factor C. Checking the transitivity rule aims to find out the indirect relationship between factors. The reachability matrix must be checked for the transitivity rule and updated until full transitivity is achieved, marked by a change from 0 to 1*. It can be seen in below table:

Table 4. 10 Transitivity Matrix

Code	F1	F2	F3	F4	F5	F6	F7	F8
F1	1	1	1*	0	1	1*	1*	1*
F2	1	1	1	0	0	1*	1*	1*
F3	1	1*	1	0	0	1*	1	1*
F4	0	0	0	1	1*	1	1	1
F5	1*	0	0	1	1	1*	1	1*
F6	1	1	1	1	1	1	1	1*
F7	1	1	1	1	1*	1*	1	1*
F8	1	1	1	1*	1	1	1	1

4.4.3 Final Initial Reachability Matrix (FRM)

To make the final reachability matrix, the numeric symbol 1* is replaced by 1, leaving the numeric value of 0 unchanged. This matrix yields the driving power values as a

horizontal sum and the dependence power values as a vertical and the result that have been changed can be seen below:

Table 4. 11 FRM Matrix

Code	F1	F2	F3	F4	F5	F6	F7	F8
F1	1	1	1	0	1	1	1	1
F2	1	1	1	0	0	1	1	1
F3	1	1	1	0	0	1	1	1
F4	0	0	0	1	1	1	1	1
F5	1	0	0	1	1	1	1	1
F6	1	1	1	1	1	1	1	1
F7	1	1	1	1	1	1	1	1
F8	1	1	1	1	1	1	1	1

4.4.4 Reachability set, Attendance set and Intersection

Next, create a reachability set and an attendance set and reachability set is a collection of factors that can be reached or influenced by a particular factor. It can be said from the final data of the Initial Reachability Matrix that each 1 in a row means that the factor influences another factor. And an attendance set is a collection of factors that influence a particular factor, meaning each 1 in a column influences that factor, and the goal is to find the level in the diagram.

Table 4. 12 Reachability set, Attendance set and Intersection

Code	Reachability Set	Antecedent Set	Intersection	Level
F1	F1, F2, F3, F5, F6, F7, F8	F1, F2, F3, F5, F6, F7, F8	F1, F2, F3, F5, F6, F7, F8	3
F2	F1, F2, F3, F6, F7, F8	F1, F2, F3, F6, F7, F8	F1, F2, F3, F6, F7, F8	3
F3	F1, F2, F3, F6, F7, F8	F1, F2, F3, F6, F7, F8	F1, F2, F3, F6, F7, F8	3
F4	F4, F5, F6, F7, F8	F4, F5, F6, F7, F8	F4, F5, F6, F7, F8	1
F5	F1, F4, F5, F6, F7, F8	F1, F4, F5, F6, F7, F8	F1, F4, F5, F6, F7, F8	2
F6	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	3
F7	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	3
F8	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	3

Based on the ISM results, it is shown that the factors in this system are closely interconnected. Some factors have a significant influence on others, while others are more influenced by others. Factors at Level 3 (such as F1, F2, F3, F6, F7 and F8) are important because they affect many other factors and are themselves affected by them. In other words, these factors are key factors in an interconnected system and, the Level 2 factors (F5) are connecting factors that influence and are influenced by other factors. This factor has a significant

influence but are not as strong as the Level 3 factors. These factors play an important role in connecting various factors in the system but are not as dominant as the Level 3 factors, which have a greater influence. Meanwhile, F4, at Level 1, is more influenced by other factors and has little influence on others. This means that F4 is more dependent on other factors in the system and does not play a significant role in changing the system as a whole.

4.4.5 Partition Level

For level partitioning, we use an iteration system. Each iteration focuses on factors not yet assigned to a level and excludes factors already assigned to the previous level. Here is the updated iteration process, where each iteration focuses only on factors not yet assigned to a level, based on the Reachability Set, Antecedent Set, and Intersection.

Table 4. 13 Iteration Level 1

Code	Reachability Set	Antecedent Set	Intersection	Level
F1	F1, F2, F3, F5, F6, F7, F8	F1, F2, F3, F5, F6, F7, F8	F1, F2, F3, F5, F6, F7, F8	
F2	F1, F2, F3, F6, F7, F8	F1, F2, F3, F6, F7, F8	F1, F2, F3, F6, F7, F8	
F3	F1, F2, F3, F6, F7, F8	F1, F2, F3, F6, F7, F8	F1, F2, F3, F6, F7, F8	
F4	F4, F5, F6, F7, F8	F4, F5, F6, F7, F8	F4, F5, F6, F7, F8	1
F5	F1, F4, F5, F6, F7, F8	F1, F4, F5, F6, F7, F8	F1, F4, F5, F6, F7, F8	
F6	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	
F7	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	
F8	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	F1, F2, F3, F4, F5, F6, F7, F8	

Table 4. 14 Iteration Level 2

Code	Reachability Set	Antecedent Set	Intersection	Level
F1	F1, F2, F3	F1, F2, F3	F1, F2, F3	
F2	F1, F2, F3	F1, F2, F3	F1, F2, F3	
F3	F1, F2, F3	F1, F2, F3	F1, F2, F3	
F5	F1	F1	F1	2
F6	F1, F2, F3,	F1, F2, F3	F1, F2, F3	
F7	F1, F2, F3,	F1, F2, F3	F1, F2, F3	
F8	F1, F2, F3	F1, F2, F3	F1, F2, F3	

Table 4. 15 Iteration Level 3

Code	Reachability Set	Antecedent Set	Intersection	Level
F1	F2, F3	F2, F3	F2, F3	3
F2	F2, F3	F2, F3	F2, F3	3
F3	F2, F3	F2, F3	F2, F3	3
F6	F2, F3	F2, F3	F2, F3	3
F7	F2, F3	F2, F3	F2, F3	3
F8	F2, F3	F2, F3	F2, F3	3

4.4.6 Conical Matrix

After finish making an FRM we can find the Driving power and Dependence power, we can see that on this conical matrix:

Table 4. 16 Conical Matrix

Code	F1	F2	F3	F4	F5	F6	F7	F8	Driving Power
F1	1	1	1	0	1	1	1	1	7
F2	1	1	1	0	0	1	1	1	6
F3	1	1	1	0	0	1	1	1	6
F4	0	0	0	1	1	1	1	1	5
F5	1	0	0	1	1	1	1	1	6
F6	1	1	1	1	1	1	1	1	8
F7	1	1	1	1	1	1	1	1	8
F8	1	1	1	1	1	1	1	1	8
Dependence Power	7	6	6	5	6	8	8	8	

The conical matrix is derived from the Final Initial Reachability Matrix (FRM), which serves as a foundational tool in determining both Driving Power and Dependence Power of the factors within a system. By calculating the Driving Power, which represents how much a factor influences others, and the Dependence Power, which indicates how much a factor is influenced by others, the conical matrix provides essential insights. These insights are then used to facilitate the creation of the MICMAC diagram.

4.4.7 ISM Diagram

Based on the level partition calculation, an ISM diagram can be obtained to determine the key factors in detail. We can see the key factors based on the hierarchical structure and direct influence in the system:

Based on ISM diagram, F1 (Financial and economic barriers to electric vehicle adoption) is placed at Level 1, indicating that this

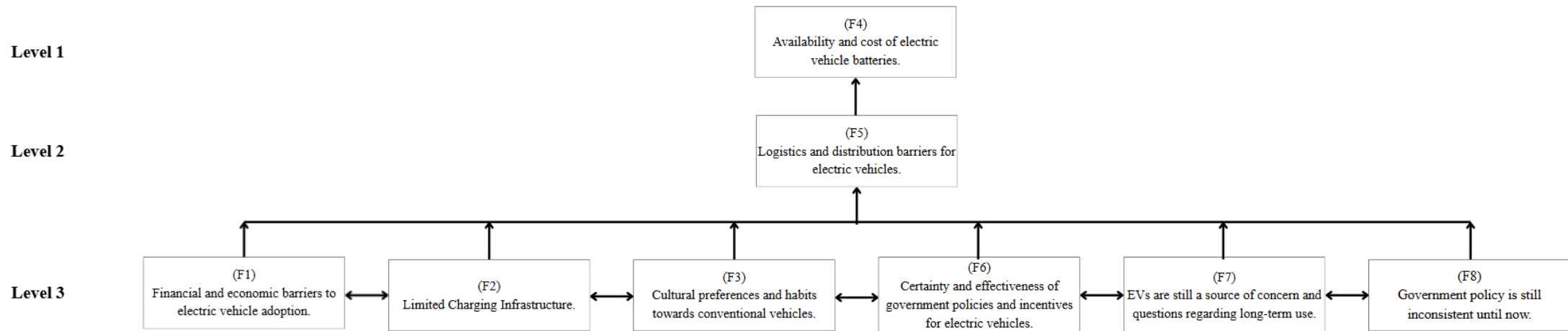


Figure 4. 1 ISM Diagram

factor is more influenced by many other factors and has a smaller influence on the electric vehicle adoption system. At Level 2, there is F5 (Logistics and distribution barriers for electric vehicles), which acts as a connecting factor in the system, influencing the distribution and availability of electric vehicles, although influenced by larger policies and infrastructure. Meanwhile, Level 3 is filled with more dominant and inter-influencing factors, namely F2 (Limited Charging Infrastructure), F3 (Cultural preferences and habits towards conventional vehicles), F6 (Certainty and effectiveness of government policies and incentives for electric vehicles),

F7 (EVs are still a source of concern and questions regarding long-term use), and F8 (Government policy is still inconsistent until now). These factors are the main key to why electric vehicle adoption in Indonesia is slow despite having existed for a long time, because they drive the system through influences on charging infrastructure, cultural preferences, and government policies that directly influence people's decisions to adopt electric vehicles.

CHAPTER V

RESULT AND DISCUSSION

5.1 Data Validation Analysis

5.1.1 Analysis of eliminated validation items

Based on the data processing results, several factors influencing electric vehicle adoption in Indonesia were deemed irrelevant and were not considered for further analysis. Factors such as F2 (Awareness and knowledge of electric vehicles), although important, were deemed less relevant because electric vehicles have been in Indonesia for a long time, and moreover, people can learn about electric vehicles through the internet. F6 (Manufacturing and production challenges) was also not considered a priority because it is more influenced and limited by government policy and incentive factors. Similarly, F8 (Variety and availability of electric vehicle models) had less influence on electric vehicle adoption in Indonesia, as it is more important to focus on efficient and affordable models. F9 (Public perception of the reliability, safety, and durability of electric vehicles) and F11 (Suitability of electric vehicles to geographical conditions) were also deemed less relevant to adoption, because other factors such as government policy and the development of charging infrastructure are more urgent to address. In addition, factors related to public understanding of electric vehicles F12 (The level of public understanding about how electric vehicles work, charge and maintain them) and technician skills F13 (The level of skilled technicians in Indonesia didn't the same as the other countries) are also not considered relevant because in fact there are now quite a lot of EV companies in Indonesia and therefore technicians specialized in electric vehicles continue to grow. Overall, the adoption of electric vehicles in Indonesia is highly dependent on the consistency of government policies, the development of charging infrastructure, and incentives that support the price of electric vehicles, which need to be prioritized to spur widespread adoption of electric vehicles.

5.1.2 Relevant validation analysis

Based on the validation results, factors with high Kappa and I-CVI values were deemed relevant and valid for further analysis. These factors include F1 (Financial and economic barriers to electric vehicle adoption), F3 (Limited Charging Infrastructure), F4 (Cultural preferences and habits toward conventional vehicles), F5 (Availability and cost of electric vehicle batteries), F7 (Logistics and distribution barriers for electric vehicles),

F10 (Certainty and effectiveness of government policies and incentives for electric vehicles), F14 (EVs are still a source of concern and questions regarding long-term use), and F15 (Government policy is still inconsistent until now). These factors had high I-CVI and Kappa values, indicating good validity and strong agreement among experts.

F1, which is financial and economic barriers to electric vehicle adoption, is considered relevant because the high price compared to conventional vehicles is a major barrier. F3 (Limited Charging Infrastructure) and F5 (Availability and cost of electric vehicle batteries) are also considered very important because inadequate charging infrastructure and high battery costs are major barriers to electric vehicle adoption. Furthermore, F4 (Cultural preferences and habits towards conventional vehicles) plays a significant role in electric vehicle adoption, as people tend to prefer more practical fossil-fueled vehicles. F7 (Logistics and distribution barriers for electric vehicles) and F10 (Certainty and effectiveness of government policies and incentives for electric vehicles) are factors that play a role in overcoming distribution challenges and creating policies that can encourage the public to adopt electric vehicles. Factors F14 (EVs are still a source of concern and questions regarding long-term use) and F15 (Government policy is still inconsistent until now) demonstrate the importance of policy certainty and public trust in the reliability and sustainability of electric vehicles.

5.2 MICMAX Analysis

In the context of the influence of factors inhibiting the adoption of electric vehicles in Indonesia, MICMAC analysis is relevant for identifying relationships between variables and determining the factors that have the strongest influence (driving power) and those that are most influenced by other variables (dependence power). This approach helps in understanding the hierarchical structure of the strategy elements that have been identified using ISM, thus enabling the development of more effective and focused strategies, as shown in diagram below:

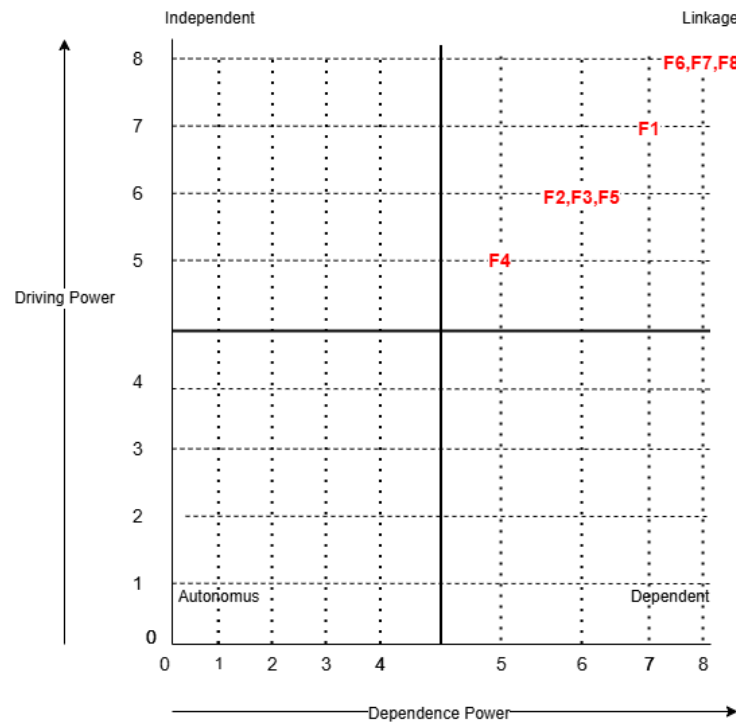


Figure 5. 1 MICMAC Diagram

In the Autonomous quadrant or quadrant 1, factors typically have low driving power and low dependence power, meaning they have little influence on the system and are not significantly influenced by other factors. However, in this diagram, no factors fall into this quadrant, indicating that all analyzed factors are strongly interconnected and influence each other in the electric vehicle adoption process.

And in quadrant 2, there are no factors in the Dependent quadrant in this diagram. Typically, this quadrant contains factors that have high dependence power but low driving power, meaning they are strongly influenced by many other factors but have little influence on others. In this context, all factors have a significant influence on each other, so no factor is solely influenced without affecting the system as a whole.

In quadrant 3, all factors are in the Linkage quadrant: F6 (Certainty and effectiveness of government policies and incentives for electric vehicles), F7 (EVs are still a source of concern and questions regarding long-term use), F8 (Government policy is still inconsistent until now), F1 (Financial and economic barriers to electric vehicle adoption), F2 (Limited Charging Infrastructure), F3 (Cultural preferences and habits towards conventional vehicles), F5 (Availability and cost of electric vehicle batteries), and F4 (Cultural preferences and habits towards conventional vehicles), have high driving power and dependence power, indicating that they influence and are

interdependent on each other. These factors are the main drivers in an interconnected system, where changes in one factor can affect the others. For example, F6, which relates to effective and consistent government policies, will be directly related to F7, which focuses on public trust in electric vehicles. F1, regarding the cost of electric vehicles, also interacts closely with F5, related to the high cost of batteries, which together become barriers to electric vehicle adoption. Furthermore, F4, which is related to cultural preferences for conventional vehicles, plays a significant role in the adoption process of electric vehicles, as people's habits that prefer fossil-fueled vehicles will hinder the adoption of electric vehicles. Therefore, to accelerate the adoption of electric vehicles, these factors must be considered comprehensively because they influence and depend on each other.

In quadrant 4, or independent, no factors fall into this quadrant, meaning all factors are interdependent in the adoption of electric vehicles. Typically, this quadrant contains factors with high driving power but low dependence power, meaning they influence many other factors but are not significantly influenced by others. However, in this case, all factors fall into the Linkage quadrant, indicating that in the context of electric vehicle adoption in Indonesia, no factor can stand alone without being influenced by other factors.

5.3 ISM Diagram Analysis

Based on (Sarvari et al., 2024) and (Natalia et al., 2020) elements that “trigger” many other elements (driving) tend to be “lower” in the hierarchy because they are the ones that generate upward influences, and this supports a structure where lower levels = elements that drive/are the basis will influence the levels above or can be called as an key factors.

5.3.1 Level 1

Level 1 are the results or outcome factors which include battery availability and battery prices, and wider adoption of electric vehicles, which are influenced by the lower levels. F4 (Availability and Cost of Electric Vehicle Batteries) Electric vehicles are highly dependent on the availability of efficient and affordable batteries. High battery costs and limited availability barriers that need to be addressed to increase the accessibility and attractiveness of adopting electric vehicles.

5.3.2 Level 2

Level 2 contains intermediary factors that connect drivers (level 3) with outcomes or results at higher levels. These factors are often influenced by factors at level 3 and also influence level 1. This factor is not as powerful as level 3 factors in terms of direct influence, this factor still plays a crucial role in the overall system. This factor act as intermediaries that direct or mediate the relationship between key factors and outcomes. F5 (Logistics and Distribution Barriers for Electric Vehicles) Delivering electric vehicles throughout Indonesia's vast territory can be challenging. Without an efficient distribution system and strong logistical support, electric vehicles will not be evenly distributed, especially in areas far from major cities.

5.3.3 Level 3

Level 3 contains the key drivers, the most fundamental elements that have a strong influence on the system or process being analyzed. In the context of electric vehicle adoption, factors at this level typically represent barriers or obstacles that must be overcome to drive change. F1 (Financial and Economic Barriers to Electric Vehicle Adoption). The high cost of electric vehicles is one of the main reasons why electric vehicle adoption has not been optimal in Indonesia. Cost reductions, incentives, and supportive financial policies are needed to encourage wider adoption. F2 (Limited Charging Infrastructure) Limited electric vehicle charging infrastructure is a crucial factor in driving electric vehicle adoption. Without an adequate charging network, people will find it difficult and uncertain to adopt electric vehicles. F3 (Cultural Preferences and Habits Towards Conventional Vehicles) Indonesians accustomed to fossil-fueled vehicles tend to be more reluctant to adopt electric vehicles. Habits and dependence on conventional vehicles are among the main factors slowing the adoption to electric vehicles. F6 (Certainty and Effectiveness of Government Policies and Incentives for Electric Vehicles) The successful adoption of electric vehicles depends heavily on clear, consistent, and effective government policies. Without supportive policies, such as fiscal incentives and regulations that facilitate electric vehicle adoption, decision-making regarding electric vehicle adoption will be hampered. F7 (EVs Are Still a Source of Concern and Questions Regarding Long-Term Use) Many consumers remain uncertain about the long-term sustainability of electric vehicles, both in terms of battery life, maintenance costs, and reliability. This uncertainty is a significant inhibiting factor in accelerating electric vehicle adoption. F8 (Government

Policy Is Still Inconsistent Until Now) Uncertainty and inconsistency in government policies supporting electric vehicles in Indonesia have made people and companies hesitant to invest in this technology. Unclear policies on taxes, incentives, and infrastructure support can hinder the adoption of electric vehicles.

5.3.4 Strategy

Below is a comprehensive strategy to address barriers to electric vehicle (EV) adoption in Indonesia, based on the ISM Diagram, which maps key elements from Level 3 (drivers) to Level 1 (outcomes). This strategy will address issues such as high costs, limited charging infrastructure, inconsistent policies, and cultural barriers:

1. Availability and cost of electric vehicle batteries (Level 1: F4)

(Lazuardy et al., 2024) says EV market share growth in Indonesia remains very low, despite ambitious targets. For example, one study found that EVs account for only 1.47% of conventional vehicles in Indonesia because the price is high compared to conventional vehicle. Therefore, the following strategy is recommended:

- a. The government should provide direct subsidies for EV purchases, tax incentives for consumers, and vehicle tax reductions for EV buyers.
- b. Long-Term Financing Facilities: Provide low-interest financing with long installments through partnerships with local financial institutions.
- c. Production Cost Reductions: The government can provide subsidies to local battery factories to lower EV production costs.

2. Logistics and distribution barriers for electric vehicles. (Level 5: F5)

According to (Lin et al., 2025) Distribution/logistics noted that to date Indonesia reported around 1,400 charging stations, consisting of 439 public stations and 961 battery swap stations, a number that is clearly far from the projected need. Therefore, the following strategies are recommended:

- a. Provide incentives for dealers who open EV distribution points outside major cities.
- b. Encourage the use of e-commerce platforms to facilitate access to electric vehicles, including delivery to remote areas.
- c. Building an integrated distribution system using e-commerce that enables online EV purchases and delivery to consumer locations throughout Indonesia.

3. Financial and economic barriers to electric vehicle adoption (Level 3: F1)

The most frequently cited barriers are high initial purchase prices and inadequate charging infrastructure. A study by (Candra, 2022) concluded that "high initial purchase prices, insufficient charging infrastructure, and a lack of government incentives are key barriers to EV adoption in Indonesia. And here's the strategy that can help:

- a. The government should provide direct subsidies for EV purchases, tax incentives for consumers, and vehicle tax reductions for EV buyers.
- b. Long-Term Financing Facilities: Provide low-interest financing with long installments through partnerships with local financial institutions.
- c. The government can provide subsidies to local battery factories to lower EV production costs.

4. Limited Charging Infrastructure (Level 3: F2)

Regarding charging infrastructure: a special study shows that to support electric passenger cars in Indonesia, approximately 31,859 charging stations are needed by 2030, while PLN's projection is only around 24,720 stations in the business-as-usual scenario (Tenny Kristiana et al., 2024) and here's the strategy:

- a. The government and private sector must accelerate the development of charging stations in major cities, remote areas, and along major toll roads.
- b. Fast Charging Infrastructure: Encourage the use of fast charging, which can reduce waiting times for EV users.
- c. Renewable Energy Sources: Ensure that charging stations throughout Indonesia use renewable energy (e.g., solar or wind power).

5. Cultural preferences and habits towards conventional vehicles (Level 4: F3)

The surveys by (PwC Indonesia, 2024) shows one of the reasons people avoid EV adoption is due to range anxiety and uncertainty about battery lifespan. This indicates that while environmental concerns may exist, practical concerns about EV usage are preventing mass adoption and are less of a concern when people use conventional vehicles. And this is the strategy:

- a. Launch nationwide advertising campaigns showcasing the environmental and cost-saving benefits of EVs. These campaigns can include TV ads,

social media outreach, and public service announcements to emphasize the reduction of CO₂ emissions and lower maintenance costs.

- b. Collaboration with influencers and celebrities to advocate for EV adoption, making the transition more relatable and aspirational for the masses.
 - c. Highlight the long-term financial benefits, focusing on the lower operational costs (fuel, maintenance) and the reduced dependence on fossil fuels.
6. Certainty and effectiveness of government policies and incentives for electric vehicles and Government policy is still inconsistent until now. (Level 3: F6, F8) (Hasjanah & Simanjuntak, 2023) says Presidential Regulation No. 55 of 2019 concerning the Electric Vehicle Program includes policies to support EV adoption, but implementation of these policies has not been aligned with action on the ground, particularly regarding fiscal incentives and poorly coordinated infrastructure development. The Indonesian government has also not established a stable long-term incentive policy. Here's the strategy that may related:
- a. Implement a carbon tax policy for fossil-fueled vehicles and provide tax incentives for EVs.
 - b. Develop simpler regulations regarding electric vehicle imports, battery subsidies, and electric vehicle taxes.
 - c. The government needs to create an EV development roadmap that includes long-term fiscal incentives, supportive regulations, and investment in local EV infrastructure and production.
 - d. Optimize incentives for local EV manufacturers developing electric vehicles in Indonesia.

7. EVs are still a source of concern and questions regarding long-term use. (Level 3: F7)

Research from (PwC Indonesia, 2024) Concerns about battery life, maintenance costs, and long-term durability of EVs remain major barriers to electric vehicle adoption in Indonesia. Consumers often worry that EVs will break down more quickly or incur higher operating costs than fossil-fueled vehicles after several years of use. And this is the strategy:

- a. Introduce long warranties for EV batteries (e.g., 8-10 years) and provide affordable maintenance services at authorized service centers.

- b. Provide regular technology updates to improve EV battery life.
- c. Provide information about long-term maintenance and lower cost savings compared to conventional vehicles.

CHAPTER VI

CONCLUSION AND SUGGESTION

6.1 Conclusion

Based on the analysis the factors that influence that slowing adoption of electric vehicle in Indonesia using the ISM method, the conclusion can be drawn, as follows:

1. The key factors and the driver factor is F1 (Financial and Economic Barriers to Electric Vehicle Adoption), F2 (Limited Charging Infrastructure), F3 (Cultural Preferences and Habits Towards Conventional Vehicles), F6 (Certainty and Effectiveness of Government Policies and Incentives for Electric Vehicles), F7 (EVs Remain a Source of Concern and Questions Regarding Long-Term Use), F8 (Government policy is still inconsistent until now) and also the results of the previous discussion obtained a relationship between factors that are interrelated with each other, from the driving factor at level 3 pushing to level 2 and so on to level 1. The adoption of Electric vehicles in Indonesia is still considered difficult because many key factors cause the adoption of Electric vehicles in Indonesia to be slow and all factors have a large reachability set and antecedent set and can be interpreted in the MICMAC analysis as entering quadrant 2, namely linkage or factors that have a strong relationship with each other.
2. Challenges in the electric vehicle supply chain in Indonesia, particularly those related to raw material procurement for batteries, manufacturing, and logistics, significantly impact electric vehicle adoption. Although Indonesia has abundant natural resources such as nickel, cobalt, and lithium, reliance on imports and a lack of local manufacturing infrastructure are major obstacles to mass-producing batteries. Furthermore, high production costs and inefficient distribution logistics, particularly outside major cities, also hinder the availability of electric vehicles. To accelerate adoption, investment in local raw material processing, increased battery manufacturing capacity, and the development of broader and more efficient distribution and charging infrastructure are needed.
3. Interpretive Structural Modelling (ISM) method is a highly effective approach for mapping and analyzing the relationships between factors influencing electric vehicle adoption. Using ISM, we can identify and deeply understand key factors and see the relation between the factor that can accelerate or hinder the transition to

electric vehicles. Furthermore, ISM also provides valuable insights into the priority factors that policymakers and industry need to prioritize to accelerate electric vehicle adoption. Through this approach, the relationships between various factors, such as government policy, infrastructure, public perception, EV supply chain, price of EV and EV durability can be systematically analyzed, resulting in more targeted strategic recommendations to encourage a faster and more effective transition to electric vehicles in Indonesia this method are the best for this research because ISM can find the key factors and ISM can find the relationship between the factors.

6.2 Suggestion

Based on the course of this research, several valuable insights have been gained. These lessons can serve as reflections and be applied to guide and improve future studies.

1. Industry and government need to prioritize to accelerate electric vehicle adoption. Through this approach, the relationships between various factors, such as government policy, infrastructure, public perception, EV supply chain and price can be regularly analyzed, resulting in more targeted strategic recommendations to encourage a faster and more effective adoption electric vehicles in Indonesia.
2. For further research, it is recommended to conduct a more in-depth analysis of the influence of government policies and fiscal incentives on electric vehicle adoption, as well as evaluate the effectiveness of policies implemented in countries with higher EV adoption rates. Research can also explore aspects of more innovative and environmentally friendly battery technology, and their impact on production costs and selling prices of electric vehicles. Furthermore, it is recommended to further examine the social and psychological factors that influence consumer decisions in choosing electric vehicles, such as model preferences, perceived reliability, and comfort factors. By expanding the scope of research, it is hoped that more comprehensive solutions can be found to accelerate the transition to electric vehicles in Indonesia, as well as provide more detailed guidance for policymakers and related industries.

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APPENDIX

QUESTIONNAIRE INSTRUCTIONS

1. The questionnaire is completed by assessing the relationship between item A and item B for factors inhibiting electric vehicle adoption in Indonesia, as validated from the previous questionnaire.

The relationship between items is assessed using four symbols:

- V = Item A influences item B, but not vice versa.
- A = Item B influences item A, but not vice versa.
- X = Item A and B influence each other.
- O = Item A and B do not influence each other.

You will fill in **ONE SYMBOL** that best represents the relationship between the related strategies.

2. This questionnaire contains 28 questions with an estimated time of 30 minutes.
3. The questionnaire is based on your experience and knowledge. There are no right or wrong answers; please answer based on your knowledge and experience.
4. If there is anything you do not understand, please ask the researcher.

EXAMPLE OF FILLING OUT THE QUESTIONNAIRE

No	Code	Question	Assessment Item		V,A,X,O Assesement
1.	F1-F2	Determine the relationship between “Financial and economic barriers to electric vehicle adoption” and “Limited Charging Infrastructure.”	V	“Financial and economic barriers to electric vehicle adoption” Influence “Limited Charging Infrastructure.”	V
			A	“Limited Charging Infrastructure” Influence “Financial and economic barriers to electric vehicle adoption.”	
			X	Both influence each other	

No	Code	Question	Assessment Item		V,A,X,O Assesement
			O	Both of them do not influence each other	

No	Code	Question	Assessment Item		V,A,X,O Assesement
1.	F1-F2	Determine the relationship between “Financial and economic barriers to electric vehicle adoption” and “Limited Charging Infrastructure.”	V	“Financial and economic barriers to electric vehicle adoption” Influence “Limited Charging Infrastructure.”	
			A	“Limited Charging Infrastructure” Influence “Financial and economic barriers to electric vehicle adoption.”	
			X	Both influence each other	
			O	Both of them do not influence each other	

2	F1-F3	Determine the relationship between “Financial and economic barriers to electric vehicle adoption” and “Cultural preferences and habits towards conventional vehicles.”	V	“Financial and economic barriers to electric vehicle adoption” Influence “Cultural preferences and habits towards conventional vehicles.”	
			A	“Cultural preferences and habits towards conventional vehicles” Influence “Financial and economic barriers to electric vehicle adoption.”	
			X	Both influence each other	
			O	Both of them do not influence each other	

3	F1-F4	Determine the relationship between “Financial and economic barriers to electric vehicle adoption” and “Availability and cost of electric vehicle batteries.”	V	“Financial and economic barriers to electric vehicle adoption” Influence “Availability and cost of electric vehicle batteries.”	
			A	“Availability and cost of electric vehicle batteries” Influence “Financial and economic barriers to electric vehicle adoption.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
4	F1-F5	Determine the relationship between “Financial and economic barriers to electric vehicle adoption” and “Logistics and distribution barriers for electric vehicles.”	V	“Financial and economic barriers to electric vehicle adoption” Influence “Logistics and distribution barriers for electric vehicles.”	
			A	“Logistics and distribution barriers for electric vehicles” Influence “Financial and economic barriers to electric vehicle adoption”	
			X	Both influence each other	
			O	Both of them do not influence each other	
5	F1-F6	Determine the relationship between “Financial and economic barriers to electric vehicle adoption” and “Certainty and effectiveness of government policies and incentives for electric vehicles.”	V	“Financial and economic barriers to electric vehicle adoption” Influence “Certainty and effectiveness of government policies and incentives for electric vehicles.”	
			A	“Certainty and effectiveness of government policies and incentives for electric vehicles.” Influence “Financial and economic barriers to electric vehicle adoption.”	
			X	Both influence each other	
			O	Both of them do not influence each other	

6	F1-F7	Determine the relationship between “Financial and economic barriers to electric vehicle adoption” and “EVs are still a source of concern and questions regarding long-term use.”	V	“Financial and economic barriers to electric vehicle adoption” Influence “EVs are still a source of concern and questions regarding long-term use.”	
			A	“EVs are still a source of concern and questions regarding long-term use” Influence “Financial and economic barriers to electric vehicle adoption.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
7	F1-F8	Determine the relationship between “Financial and economic barriers to electric vehicle adoption” and “Government policy is still inconsistent until now.”	V	“Financial and economic barriers to electric vehicle adoption” Influence “Government policy is still inconsistent until now” Influence.”	
			A	“Government policy is still inconsistent until now” Influence “Financial and economic barriers to electric vehicle adoption	
			X	Both influence each other	
			O	Both of them do not influence each other	
8	F2-F3	Determine the relationship between “Limited Charging Infrastructure.” and “Cultural preferences and habits towards conventional vehicles.”	V	“Limited Charging Infrastructure.” Influence “Cultural preferences and habits towards conventional vehicles.”	
			A	“Cultural preferences and habits towards conventional vehicles.” Influence “Limited Charging Infrastructure.”	
			X	Both influence each other	
			O	Both of them do not influence each other	

9	F2-F4	Determine the relationship between “Limited Charging Infrastructure.” and “Availability and cost of electric vehicle batteries.”	V	“Limited Charging Infrastructure.” Influence “Availability and cost of electric vehicle batteries.”	
			A	“Availability and cost of electric vehicle batteries.” Influence “Limited Charging Infrastructure.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
10	F2-F5	Determine the relationship between “Limited Charging Infrastructure.” and “Logistics and distribution barriers for electric vehicles.”	V	“Limited Charging Infrastructure.” Influence “Logistics and distribution barriers for electric vehicles.”	
			A	“Logistics and distribution barriers for electric vehicles.” Influence “Limited Charging Infrastructure.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
11	F2-F6	Determine the relationship between “Limited Charging Infrastructure.” and “Certainty and effectiveness of government policies and incentives for electric vehicles.	V	“Limited Charging Infrastructure.” Influence “Certainty and effectiveness of government policies and incentives for electric vehicles.	
			A	“Certainty Influence effectiveness of government policies and incentives for electric vehicles.” Influence “Limited Charging Infrastructure	
			X	Both influence each other	
			O	Both of them do not influence each other	
12	F2-F7	Determine the relationship between “Limited Charging Infrastructure.” and “EVs are still a source of concern and questions regarding long-term use.”	V	“Limited Charging Infrastructure.” Influence “EVs are still a source of concern and questions regarding long-term use.	

			A	“EVs are still a source of concern and questions regarding long-term use” Influence “Limited Charging Infrastructure.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
13	F2-F8	Determine the relationship between “Limited Charging Infrastructure.” and “Government policy is still inconsistent until now.”	V	“Limited Charging Infrastructure.” Influence “Government policy is still inconsistent until now.”	
			A	“Government policy is still inconsistent until now.” Influence “Limited Charging Infrastructure.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
14	F3-F4	Determine the relationship between “Cultural preferences and habits towards conventional vehicles.” and “Availability and cost of electric vehicle batteries.”	V	“Cultural preferences and habits towards conventional vehicles.” Influence “Availability and cost of electric vehicle batteries.”	
			A	“Availability and cost of electric vehicle batteries.” Influence “Cultural preferences and habits towards conventional vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
15	F3-F5	Determine the relationship between “Cultural preferences and habits towards conventional vehicles.” and “Logistics and distribution barriers for electric vehicles.”	V	“Cultural preferences and habits towards conventional vehicles.” Influence “Logistics and distribution barriers for electric vehicles.”	
			A	“Logistics and distribution barriers for electric vehicles.” Influence “Cultural preferences and habits towards conventional vehicles.”	
			X	Both influence each other	

			O	Both of them do not influence each other	
16	F3-F6	Determine the relationship between “Cultural preferences and habits towards conventional vehicles.” and “Certainty and effectiveness of government policies and incentives for electric vehicles.”	V	“Cultural preferences and habits towards conventional vehicles.” Influence “Certainty and effectiveness of government policies and incentives for electric vehicles.”	
			A	“Certainty and effectiveness of government policies and incentives for electric vehicles.” Influence “Cultural preferences and habits towards conventional vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
17	F3-F7	Determine the relationship between “Cultural preferences and habits towards conventional vehicles.” and “EVs are still a source of concern and questions regarding long-term use.”	V	“Cultural preferences and habits towards conventional vehicles.” Influence “EVs are still a source of concern and questions regarding long-term use.”	
			A	“EVs are still a source of concern and questions regarding long-term use.” Influence “Cultural preferences and habits towards conventional vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
18	F3-F8	Determine the relationship between “Cultural preferences and habits towards conventional vehicles.” and “Government policy is still inconsistent until now.”	V	“Cultural preferences and habits towards conventional vehicles.” Influence “Government policy is still inconsistent until now.”	

			A	“Government policy is still inconsistent until now.” Influence “Cultural preferences and habits towards conventional vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
19	F4-F5	Determine the relationship between “Availability and cost of electric vehicle batteries.” and “Logistics and distribution barriers for electric vehicles.”	V	“Availability and cost of electric vehicle batteries.” Influence “Logistics and distribution barriers for electric vehicles.”	
			A	“Logistics and distribution barriers for electric vehicles.” Influence “Availability and cost of electric vehicle batteries.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
20	F4-F6	Determine the relationship between “Availability and cost of electric vehicle batteries.” and “Certainty and effectiveness of government policies and incentives for electric vehicles.”	V	“Availability and cost of electric vehicle batteries.” Influence “Certainty and effectiveness of government policies and incentives for electric vehicles.”	
			A	“Certainty and effectiveness of government policies and incentives for electric vehicles.” Influence “Availability and cost of electric vehicle batteries.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
21	F4-F7	Determine the relationship between “Availability and cost of electric vehicle batteries.” and “EVs are still a	V	“Availability and cost of electric vehicle batteries.” Influence “EVs are still a source of concern and questions regarding long-term use.”	

		source of concern and questions regarding long-term use.”	A	“EVs are still a source of concern and questions regarding long-term use.” Influence “Availability and cost of electric vehicle batteries.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
22	F4-F8	Determine the relationship between “Availability and cost of electric vehicle batteries.” and “Government policy is still inconsistent until now.”	V	“Availability and cost of electric vehicle batteries.” Influence “Government policy is still inconsistent until now.”	
			A	“Government policy is still inconsistent until now.” Influence “Availability and cost of electric vehicle batteries.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
23	F5-F6	Determine the relationship between “Logistics and distribution barriers for electric vehicles.” and “Certainty and effectiveness of government policies and incentives for electric vehicles.”	V	“Logistics and distribution barriers for electric vehicles.” Influence “Certainty and effectiveness of government policies and incentives for electric vehicles.”	
			A	“Certainty and effectiveness of government policies and incentives for electric vehicles.” Influence “Logistics and distribution barriers for electric vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
24	F5-F7	Determine the relationship between “Logistics and distribution barriers for electric vehicles.” and “EVs are	V	“Logistics and distribution barriers for electric vehicles.” Influence “EVs are still a source of concern and questions regarding long-term use.”	

		still a source of concern and questions regarding long-term use.”	A	“EVs are still a source of concern and questions regarding long-term use.” Influence “Logistics and distribution barriers for electric vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
25	F5-F8	Determine the relationship between “Logistics and distribution barriers for electric vehicles.” and “Government policy is still inconsistent until now.”	V	“Logistics and distribution barriers for electric vehicles.” Influence “Government policy is still inconsistent until now.”	
			A	“Government policy is still inconsistent until now.” Influence “Logistics and distribution barriers for electric vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
26	F6-F7	Determine the relationship between “Certainty and effectiveness of government policies and incentives for electric vehicles.” and “EVs are still a source of concern and questions regarding long-term use.”	V	“Certainty and effectiveness of government policies and incentives for electric vehicles.” Influence “EVs are still a source of concern and questions regarding long-term use.”	
			A	“Influence “EVs are still a source of concern and questions regarding long-term use.” Influence “Certainty and effectiveness of government policies and incentives for electric vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
27	F6-F8	Determine the relationship between “Certainty and effectiveness of government policies and incentives for	V	“Certainty and effectiveness of government policies and incentives for electric vehicles.” Influence “Government policy is still inconsistent until now.”	

		electric vehicles.” and “Government policy is still inconsistent until now.”	A	“Government policy is still inconsistent until now.” Influence “Certainty and effectiveness of government policies and incentives for electric vehicles.”	
			X	Both influence each other	
			O	Both of them do not influence each other	
28	F7-F8	Determine the relationship between “EVs are still a source of concern and questions regarding long-term use.” and “Government policy is still inconsistent until now.”	V	“EVs are still a source of concern and questions regarding long-term use.” Influence “Government policy is still inconsistent until now.”	
			A	“Government policy is still inconsistent until now.” Influence “EVs are still a source of concern and questions regarding long-term use.”	
			X	Both influence each other	
			O	Both of them do not influence each other	