The Impact of Electric Vehicles on the Automobile Manufacturing Clusters in Thailand

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Abstract

This research examines the profound influence of Electric Vehicles (EVs) on Thailand's automobile manufacturing sector, a key pillar of the country's economy and employment. EVs, as a sustainable transportation solution, can curtail fossil fuel consumption, greenhouse gas emissions, and air pollution. However, the adoption rate of EVs in Thailand is relatively low compared to other nations due to numerous barriers and challenges. This paper analyzed the impact of EVs on the automobile manufacturing cluster in Thailand, considering both the opportunities and threats they present. Case studies of industry leaders who have successfully integrated EV technology into their operations were examined, contributing to the projected growth of the EV market. Through an exhaustive review of literature, market analysis, and statistical evaluation, this research identified critical factors influencing the adoption of EVs in Thailand, providing a nuanced understanding of its economic implications. The study employed Porter's Diamond Model to analyze the competitive environment of the automobile manufacturing cluster, offering insights into how companies can navigate the complexities of EV integration. Recommendations are provided for automobile manufacturers to effectively harness the potential of EVs while addressing the socio-economic and regulatory challenges. This research contributes to the broader discourse on the role of EVs in transforming industries, offering a roadmap for automobile manufacturers to innovate responsibly and sustainably in the age of sustainable transportation.

Keywords: electric vehicles, automobile manufacturing cluster, Diamond Analysis.

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Name: Paing Moe Kyaw

Date: 4 April 2024

Declaration

I, Paing Moe Kyaw, hereby certify that the work embodied in this independent study entitled “The Impact of Electric Vehicles on the Automobile Manufacturing Clusters in Thailand” is result of original research and has not been submitted for a higher degree to any other university or institution.

Paing Moe Kyaw

4 May 2024

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CHAPTER 1

Introduction

1.1 Background of the Study

The automotive manufacturing industry is the largest in the world, valued at $2.9 trillion and growing at a rate of 3.1% (Binder & Rae, 2023). The industry is expected to grow even faster in the next decade, reaching $122.83 billion by 2030 (Global EV Outlook 2022 Securing Supplies for an Electric Future, 2022). The rise of electric vehicles is having a major impact on the industry, as it is driving a shift away from internal combustion engines. This is causing a paradigm shift in the automotive manufacturing cluster (Casper & Sundin, 2020).

The car industry is changing a lot because of new technology and ways of doing business, and this makes more choices for moving around, self-driving cars, electric cars, and connected cars (Winston & Karpilow, 2020). For example, the global growth in EV sales in 2021 was mainly driven by China, which contributed half of the increase. China's sales in 2021 (3.3 million) exceeded the global sales in 2020. Sales in Europe also increased significantly (up 65% to 2.3 million) after a boom in 2020, and sales in the United States recovered (to 630 000) after two years of decline. The same trends persisted in the first quarter of 2022, with China's sales more than doubling compared with the first quarter of 2021 (accounting for most of the global growth), a 60% increase in the United States and a 25% increase in Europe (Global EV Outlook, 2022).

Thai automobile industry is structured in pyramid with car makers on top and auto parts makers in lower layers by deliveries. 27 motor vehicle makers and 18 motorcycle makers. Over 90% of which are owned by multinationals. 525 suppliers in first tier and 65% of which are majority owned by foreigners. 1,760 suppliers in second and lower tiers about 70% of which are Thai owned (Thailand automotive institute, 2022). The net worth of the automobile cluster in Thailand is 1.2 trillion THB (as of 2022). This is according to a report by the Federation of Thai Industries (FTI), which was published in 2023 (Hitchcock, 2023). The report also stated that the automotive industry is a significant contributor to the Thai economy, accounting for 10% of GDP and employing over 1 million people (Statista, 2023).

Thailand's automotive industry is a significant contributor to the country's economy. The government has been supportive of the industry, and it is well-positioned for future growth. The

production of electric vehicles (EVs) will have a major impact on the automotive supply chain in Thailand, as it will require different components than internal combustion engine vehicles (ICEVs) (Thananusak, Punnakitikasem, Tanthasith, & Kongarchapatara, 2020b). For example, some parts like gearboxes and exhaust systems will become obsolete, while the demand for electric parts will keep growing. This will create opportunities for some parts and equipment manufacturers, such as those that produce electric components, batteries, wire and cable, and tires. However, other manufacturers may need to change their operations or look for new markets. The government is encouraging the EV industry with investment incentives, and there are already 664 EV charging stations in the country (Bangkok Post, 2021a).

1.2 Problems of the Study

The widespread adoption of electric vehicles (EVs) can have significant impacts on both automobile manufacturers and countries.

Researching the impact of the Electric Vehicles (EV) trend on the automobile manufacturing cluster in Thailand can involve several potential problems or challenges as follows:

1. Shifting Production: The rise of EVs requires automobile manufacturers to adapt their production processes and invest in new technologies. This involves developing electric drivetrains, battery systems, and charging infrastructure. Manufacturers need to make significant investments in research, development, and retooling to produce EVs efficiently (Van de Graaf et al., 2018).

2. Supply Chain Changes: EVs require different components compared to internal combustion engine (ICE) vehicles. Manufacturers need to adjust their supply chains to procure batteries, electric motors, and other EV-specific parts. This may involve establishing new partnerships and supplier networks (Farrell, 2019).

3. Economic and Social impact: Assessing the impact of EVs goes beyond production numbers. It requires examining the economic and social implications, such as job creation, workforce skill requirements, changes in business models, and consumer behaviour. These aspects can be challenging to quantify and measure.

4. New Competition: The EV market has attracted new entrants, including tech companies and start-ups, which compete with traditional automakers. This increases competition and requires

established manufacturers to innovate and develop compelling EV offerings to maintain market share.

5. Policy and Regulatory Environment: Government policies, incentives, and regulations play a significant role in shaping the adoption and production of EVs. Analysing the effectiveness and impact of these policies, as well as anticipating future changes, can present challenges.

To overcome these problems, researchers may need to employ a combination of methodologies, such as data analysis, surveys, interviews, case studies, and scenario modelling. Collaboration with industry experts, government agencies, and other stakeholders can provide valuable insights and help address these challenges.

1.3 Objectives of the Study

This study aims to explore the emerging market opportunities for electric vehicles in Thailand. The objectives are:

1.To identify the key stakeholders in the Thai EV market, including the government, automobile manufacturers, battery producers, and providers of charging infrastructure.

2.To develop policy and strategy recommendations to foster growth and sustainability in the Thai EV market.

3.To examine the impact of global electric vehicle trends on Thailand's automobile clusters.

1.4 Significance of the Study

This study examines the emerging market opportunities for electric vehicles (EVs) in Thailand and their relevance to the Thai automotive industry. The industry is facing a major technological shift towards EVs, as the government has set a target of having 1.2 million EVs on the road by 2036. By providing valuable insights into the key stakeholders, such as the government, automobile manufacturers, battery producers, and providers of charging infrastructure, this study will develop policy and strategy recommendations to foster growth and sustainability in the Thai EV market. These insights are essential for the Thai automotive industry to adapt its production processes, supply chains, and business models to the changing consumer preferences and environmental regulations. Furthermore, this study will assess the impact of global EV trends, such as the increasing demand, innovation, and competition, on Thailand's automobile sector. This study

contributes to the academic literature on EVs and automotive clusters by providing a comprehensive and contextualized analysis of the Thai EV market and its implications for industrial development and sustainability. This knowledge can also benefit other developing countries that seek to integrate EVs into their transportation and economic systems, as Thailand is a regional leader and a potential hub for EV production and export in Southeast Asian Countries.

1.5 Scope of the Study

This study examines the emerging market opportunities for electric vehicles (EVs) in Thailand and their relevance to the Thai automotive industry. The industry is facing a major technological shift towards EVs, as the government has set a target of having 1.2 million EVs on the road by 2036. By providing valuable insights into the key stakeholders, such as the government, automobile manufacturers, battery producers, and providers of charging infrastructure, this study will develop policy and strategy recommendations to foster growth and sustainability in the Thai EV market. These insights are essential for the Thai automotive industry to adapt its production processes, supply chains, and business models to the changing consumer preferences and environmental regulations. Furthermore, this study will assess the impact of global EV trends, such as the increasing demand, innovation, and competition, on Thailand's automobile sector. This study contributes to the academic literature on EVs and automotive clusters by providing a comprehensive and contextualized analysis of the Thai EV market and its implications for industrial development and sustainability. This knowledge can also benefit other developing countries that seek to integrate EVs into their transportation and economic systems, as Thailand is a regional leader and a potential hub for EV production and export in Southeast Asian Countries.

CHAPTER 2

Literature Review

2.1 Automotive Clusters

Automotive clusters are geographic concentrations of interconnected companies and organizations in the automotive industry. They can offer companies and organizations advantages such as economies of scale, access to specialized knowledge, and collaboration and innovation. (Tang, 2020; Zhou, 2019). Governments can support automotive clusters to help create a more competitive and sustainable automotive industry. (Zhang, 2022). Automotive clusters have been shown to play a significant role in the economic development of the regions in which they are located. They can create jobs, boost exports, and attract investment. In addition, they can help to improve the competitiveness of the automotive industry in the global market.

2.2 Industry Overview

An automobile manufacturing cluster is a geographic concentration of companies and organizations involved in the design, development, production, and distribution of automobiles. These clusters can benefit from economies of scale, knowledge spillovers, and a skilled labor pool. The Thai automotive industry ranked 10th in the world, 5th in Asia, and 1st in the ASEAN zone in terms of the total output of all vehicles in 2021. The domestic auto market was the 18th largest in the world, the 6th largest in Asia, and the 2nd largest in the ASEAN zone. Thailand's domestic production capacity for vehicles in 2022 was 3.9 million. Of this, 40% was for cars and 60% was for commercial vehicles, mostly pickups. Japanese manufacturers controlled around 80% of the total production capacity as shown in Figure 1 (krungsri, 2023).

Auto manufacturers: Income from both the domestic and export markets will rise through 2023-2025. Recurrent problems with chip shortages will continue to be seen in 2023 as the US-China tech conflict worsens, but increased investment in semiconductor production in the US, Germany, and China will pay off in the form of greater supply of chips to world markets over 2024

and 2025, and this will help to lift income for the industry (Krungsri Hi-tech Industry Outlook, 2023).

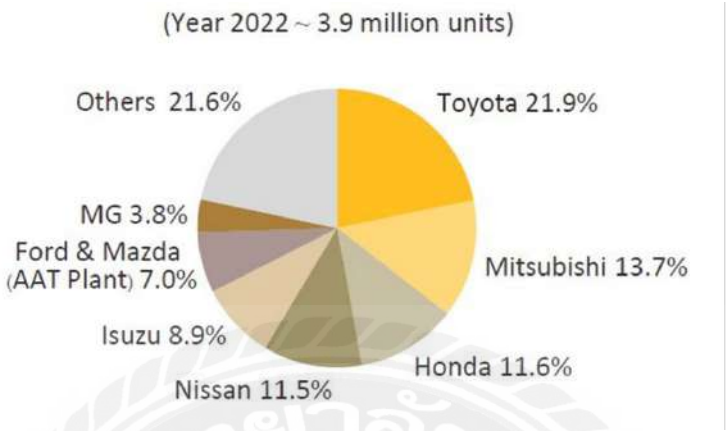


Figure 1 – Thailand vehicle production capacity (krungsri, 2023)

2.2.1 Manufacturers of passenger vehicles and 1-tonne pickups

Sales will benefit from ongoing growth in the domestic economy, continuing expansion in the online retail sector (which will add to demand for pickups), and government measures to support demand for BEVs that will run from 2022 to 2025. Sales will also be helped by the release of new models, especially of EVs, and although sluggish consumer spending power in overseas markets means that only weak growth in exports is expected for 2023, this should improve in 2024-2025 (UNLEASHING THAILAND'S ELECTRIC MOBILITY POTENTIAL, 2022).

2.2.2 Manufacturers of trucks and articulated and semi-articulated vehicles

The market for these will be boosted by government spending on the construction of infrastructure networks, with spending likely accelerating to meet phase two of the EEC development plan for 2023-2027. Sales will also benefit from growth in the logistics sector, while exporters can look forward to the prospect of greater opportunities to penetrate regional markets thanks to expanding economies and government plans to step up investment in infrastructure projects (Krungsri Hi-tech Industry Outlook, 2023).

2.2.3 Manufacturers of buses and other large transport vehicles

In this segment, recovery will move in line with a return to growth in the tourism and transport sectors over 2023 to 2025, as well as by continuing demand from public sector transport bodies, for example from the Bangkok Mass Transit Authority, and from players in the private sector in Bangkok. Moreover, as government measures that dictate the transition to the use of EVs for public transport are implemented, demand will increase by around another 6,000 vehicles. Exports will also tend to rise, especially to markets in the ASEAN zone (Krungsri Hi-tech Industry Outlook, 2023).

2.2.4 Manufacturers of motorcycles

The Thai motorcycle industry ranks sixth globally in terms of annual sales volume, highlighting its significance. This mature industry has room for further growth, driven by motorcycles being the preferred mode of transportation due to affordability and economic development in the region. Following trade agreements after 1990, the industry transitioned towards exports, solidifying Thailand's position as a major motorcycle producer. Honda and Yamaha are the dominant manufacturers in Thailand. The industry experienced a temporary setback due to COVID-19 impacting production in 2020. However, a rebound is expected by 2022, indicating the industry's resilience. Looking at the future, motorcycle sales are predicted to continue growing between 2023 and 2032, driven by a rising population and increasing consumer spending power (China Research and Intelligence, 2023).

2.3 Firm Strategy and Rivalry

Thailand's automotive industry is a dynamic battleground where established players and emerging forces clash for market dominance. Japanese manufacturers, the long-reigning champions, leverage their well-established presence to maintain a stronghold in popular segments like pick-up trucks, deeply ingrained in Thai culture and utility needs. However, new challengers, particularly Chinese automakers, are accelerating up the competition with aggressive pricing and a focus on electric vehicles (EVs), capitalizing on government incentives and growing eco-consciousness among consumers. To stay ahead, both incumbents and newcomers are increasingly forging partnerships with Thai companies, ensuring local market relevance and navigating complex

regulations. Furthermore, the race extends beyond price, with manufacturers investing heavily in research and development to bring cutting-edge technologies like autonomous driving to Thailand. Established players leverage their global brand image, while all strive to differentiate themselves through targeted marketing and strategic innovation. This multi-faceted rivalry ensures a constantly evolving Thai automotive landscape, driven by the pursuit of consumer loyalty and a competitive edge (OBE & REGALADO, 2023).

2.3.1 Established Players Leverage Existing Strongholds

Japanese automakers have a dominant presence in the Thai automotive market, accounting for over 80% of total production capacity. This dominance is due to several factors, including the early entry of Japanese automakers into the Thai market, the strong relationships they have built with the Thai government, and the high quality and reliability of their products. Japanese manufacturers, who have dominated the Thai market for decades, continue to refine their strategies. They focus on maintaining a strong presence in popular segments like pick-up trucks, which are deeply ingrained in Thai culture and utility needs. This focus on pick-up trucks is not surprising, considering that these versatile vehicles account for over a third of all vehicle sales in Thailand. They are popular for both personal and commercial use due to their durability, load-carrying capacity, and ability to navigate rough roads common in rural areas (Somchai, 2023).

2.3.2 Focus on exports

Thailand's automotive industry thrives on exports, with over 80% of production shipped internationally. This export focus stems from a combination of factors. The domestic market, though growing, can't fully utilize production capacity, making exports crucial for economies of scale. Thailand's skilled workforce, developed infrastructure, and government export incentives create a cost-effective production environment. Additionally, free trade agreements within ASEAN ease export within Southeast Asia, while ambitions of Thai automakers to become global players drive expansion into new markets beyond the region. This export focus allows Thai manufacturers to leverage their competitive advantages and establish a strong presence on the global automotive stage (Thanet, 2022).

2.3.3 Technological Innovation and Brand Image

The Thai automotive market's rising competitiveness is spurring innovation and differentiation among automakers. This translates into a focus on developing cutting-edge technologies like EVs and autonomous features, alongside tailoring vehicles to Thai preferences through features like higher ground clearance or emphasis on fuel efficiency. Furthermore, automakers are investing in building strong brand identities and targeted marketing to stand out in a crowded marketplace. This combination of innovation, localization, and strategic marketing is crucial for securing a competitive edge in Thailand's dynamic automotive industry. As environmental concerns rise, expect a continued push towards EVs and cleaner technologies, while the growing influence of social media will likely shape future marketing strategies (Siriwan, 2021)

2.3.4 Development of infrastructure and incentives

The Thai government plays a significant role in supporting the automotive industry. This support includes providing incentives for investment and exports, as well as developing infrastructure and providing training programs. The Thai government offers a variety of incentives to businesses that manufacture EVs and EV parts. These incentives include tax exemptions, import duty exemptions, and non-tax incentives. For example, the BOI offers a maximum of 8 years of corporate income tax (CIT) exemption for businesses that manufacture battery electric vehicles (BEVs). Additionally, businesses that manufacture BEVs are exempt from import duties on raw materials, machinery, and parts used in research and development (R&D). The BOI also provides similar incentives for businesses that manufacture plug-in hybrid electric vehicles (PHEVs) and hybrid electric vehicles (HEVs).For instance, businesses that manufacture BEVs must start production within 3 years of receiving a promotion certificate and must manufacture at least one of three key parts (traction motor, DCU, or BMS) within 3 years of starting car production. In addition to the above, the Thai government also supports the development of charging infrastructure for EVs. The Ministry of Energy is subsidizing charging stations, and the TISI is developing standards for EV charging systems. (Apichart, 2020).

The strategies and rivalries that shape the Thai automotive market are constantly evolving. As the market becomes more competitive, automakers will need to continue to innovate and differentiate their products in order to succeed. (Somchai, 2023)

2.4 Factor (input) conditions

Thailand has a lot of factors that make it a good place to make cars. These factors influence the customer preference on automobiles and attract supply chain companies and manufacturers from the global. Moreover, the awareness of the environmental knowledge of Thai people are increased and they want to use the new eco-friendly vehicles.

2.4.1 Low payscale

A lot of workers are skilled and have low pay. According to Kaewdang (2021), the Thai workforce is known for its high level of skills and productivity, and the cost of labor in Thailand is relatively low compared to other countries in Southeast Asia. This makes Thailand a cost-competitive location for car manufacturing.

2.4.2 Limited land usage

A lot of land is available for industrial development. Rittannon (2021) says that Thailand has a lot of lands that is suitable for industrial development. This allows car manufacturers to build large-scale factories and facilities, which can improve efficiency and productivity.

2.4.3 Supply chain and basic infrastructure development

A well-developed infrastructure, including roads, railways, and ports. Thanet (2020) explains that Thailand has a well-developed infrastructure that makes it easy to transport goods and materials to and from car manufacturing factories. This can help to reduce transportation costs and improve lead times.

2.4.4 Free Trade Agreements (FTAs)

Thailand has numerous free trade agreements with countries around the world, including major economies like China, Japan, and the United States. These FTAs can significantly reduce tariffs on exported vehicles and car parts, making Thai-made cars more competitive in the global market Thailand's strategic use of Free Trade Agreements (FTAs) acts as a significant driver for its growing electric vehicle (EV) industry. These agreements offer crucial economic advantages, making Thai-made EVs more competitive globally. FTAs significantly reduce or eliminate import

duties on EVs and their parts. This translates to lower production costs for Thai manufacturers, enabling them to offer competitive pricing in the international market. For instance, the Thailand-EU Free Trade Agreement, implemented in 2013, eliminates tariffs on Thai-made EVs exported to the European Union. This grants Thai manufacturers a substantial edge over their European counterparts, boosting their market share within the EU and solidifying Thailand's position as a prominent EV exporter (FTA, 2023).

2.4.5 Strong automotive support industry

Thailand has a well-established automotive support industry, with a network of companies supplying parts and components to car manufacturers. This reduces the reliance on imported parts and fosters a complete ecosystem within the country, streamlining production and potentially lowering costs. The Thai government also supports the car industry with policies like tax breaks, investment incentives, and export subsidies. Thai government is supporting the car industry with a 10-billion-baht stimulus package. This is one example of how the government is providing financial assistance to car manufacturers (Apichart,2020).

2.5 Demand conditions

Thailand also has a large and diverse network of car suppliers. Siriwan (2021) says that this makes it easy for car manufacturers to source the parts and components they need. This can help to reduce the risk of supply disruptions. The input factors for the car industry in Thailand are very favorable. This has helped to make Thailand a major car manufacturing hub in Southeast Asia. The Thai car industry is expected to continue to grow in the coming years, driven by demand from both domestic and export markets (“Thailand’s Automotive Industry: Market Insight for 2023,” 2022).

2.5.1 Passenger electric vehicles

The Thai automotive market is expected to grow in the coming years, driven by strong domestic demand and increasing exports. Domestic sales are expected to increase by an average of 4.0%-5.5% annually to 0.9 million vehicles per year. Exports are also predicted to increase at an average annual rate of 3.0%-4.0% to 1.1 million vehicles per year. However, overseas sales will remain somewhat weak in 2023 due to the global economic slowdown and the effects of inflation

on the cost of living. In the market of EV segment, the leading brands are mostly from China with cheap and reasonable quality cars. This is a major point to consider when compared to the famous Japanese car makers. Despite the positive outlook for the Thai automotive market, there are some negative factors that could weigh on growth, such as barriers to international trade and moves to reduce the sale or use of ICE-powered vehicles in many countries (Briefing, 2021).

The demand for electric vehicles (EVs) in Thailand surged in 2022, reaching about 15,600 units sold. This was a 48% increase from the previous year, driven mainly by the rapid growth of battery electric vehicles (BEVs), which rose by 539.7% (Chinda, 2022). The BEVs became more affordable and attractive to consumers, thanks to the government subsidies that offered between THB 70,000 and 150,000 per vehicle (Chansiri, 2021). The government also supported nine manufacturers to produce and sell various BEV models under its promotion schemes, such as the MG ZS EV, the MG EP, the ORA Good Cat, the Neta V, the MINE MT 30, the Volt City EV, the Toyota bZ4X, and the BYD ATTO 3. In addition, some other manufacturers imported and distributed BEVs without participating in the scheme, such as the Nissan LEAF, the BMW i3s, and the Tesla Model 3 and Model Y (Krung Sri auto research, c. 2023). The BEV market was dominated by Chinese manufacturers, who captured more than 80% of new registrations in 2022. The demand for EVs in Thailand is projected to continue growing and reach around 113,200 units sold by 2030 (Sripakagorn & Chinda, 2020). According to a report from the Electric Vehicle Association in

	2018	2019	2020	2021	2022
ORA (GWM)	0.00	0.00	0.00	0.00	39.96
MG	0.00	74.55	65.34	55.09	33.05
Volvo	0.00	0.00	0.00	0.47	6.41
Tesla	37.50	1.52	7.69	11.47	4.41
BYD	12.50	0.45	0.00	0.88	3.87
BMW	1.79	0.45	0.16	0.16	3.26
Porsche	0.00	0.00	1.19	10.03	3.02
Mini	0.00	0.00	0.87	4.29	2.33
Nissan	0.00	6.67	4.28	3.15	1.36
Neta	0.00	0.00	0.00	0.00	0.74
Others	48.21	16.36	20.47	14.46	1.61

Note: Passenger cars no more than 7 people
Source: Department of Land Transport, compiled by Krungsri Research

Table 1- New registered Passenger electric vehicles Market shares and rank in Thailand (% share)

Thailand, there are currently 1,482 charging stations throughout the country and 75,148 battery electric vehicle passenger cars as of the end of July 2023. According to a report from the Electric Vehicle Association in Thailand, there are currently 1,482 charging stations throughout the country, and 75,148 battery electric vehicle passenger cars are registered as of the end of June 2023 (“Current Status of EV,” 2023).

2.5.2 Thailand's Electric Motorbikes

Thailand's electric motorbike market offers a glimpse into a future powered by clean and sustainable transportation. While still in its nascent stages, the market exhibits promising signs of growth, fueled primarily by government initiatives. A crucial step forward came in February 2022 with the introduction of a government subsidy program. This program incentivizes manufacturers and distributors by offering a flat fee of 18,000 baht for each electric motorbike sold under 150,000 baht. This financial aid significantly reduces the initial cost burden for consumers, making electric motorbikes a more attractive alternative compared to traditional gasoline-powered options (Market Research for Thailand Automotive, 2023).

However, the path towards widespread electric motorbike adoption requires addressing challenges beyond just price competitiveness. Current limitations include the scarcity of readily available charging stations, which can cause "range anxiety" for potential buyers. This anxiety stems from the concern that electric motorbikes might not have enough range to meet daily commuting needs before requiring a recharge. Additionally, the technology behind electric vehicle batteries is still evolving, and their range often falls short compared to gasoline-powered counterparts. Despite these hurdles, Thailand's electric motorbike market holds significant potential. Continued government support through subsidies and infrastructure development, coupled with advancements in battery technology, can pave the way for a more sustainable transportation landscape. As the range and efficiency of electric motorbikes improve, and charging stations become more ubiquitous, consumer perception and adoption are likely to follow suit. Thailand's electric motorbike market is poised for significant growth in the coming years, offering a glimpse into a future where clean and convenient transportation becomes the norm (FOURIN, 2023).

2.6 Related Support Industries

Thailand's burgeoning electric vehicle (EV) industry is not just about the vehicles themselves. A robust ecosystem of supporting industries is crucial for its long-term success.

2.6.1 Financing and loans

The adoption of electric vehicles (EVs) depends not only on the availability and performance of EVs but also on the affordability and accessibility of EVs for consumers and businesses. The financial and loan cluster, which consists of financial institutions, regulators, and partners, is an important industry that can enable and enhance the adoption of EVs by providing financial solutions and incentives for EV stakeholders (Consumer Choice Center, 2021). For instance, the financial and loan cluster can offer loans, leases, or subscriptions for EV purchase or use, as well as green bonds or funds for EV projects or companies (EY, 2021). Additionally, the financial and loan cluster can implement policies that support or require the use of EVs, such as carbon pricing, fuel economy standards, or zero-emission vehicle mandates (IEA, 2021a). Moreover, the financial and loan cluster can collaborate with other stakeholders, such as governments, utilities, automakers, or charging providers, to develop and deploy EV infrastructure and services, such as charging stations, smart grids, or mobility platforms. By applying their financial expertise and resources, the financial and loan cluster can help facilitate the EV transition and contribute to the decarbonization and innovation of the mobility sector (IEA, 2021b).

2.6.2 Utilities and charging station infrastructure

Charging station infrastructure is crucial for the adoption of electric vehicles (EVs), as it provides various benefits to EV users and the power system (Alharbi et al., 2021). However, the demand for charging stations could outstrip the supply if EV sales grow as expected in the next decade (McKinsey & Company, 2017). Therefore, different use cases, locations, technologies, and regulations need to be considered when planning and designing charging station infrastructure. Moreover, various companies can pursue different strategic plays in the EV public-charging market, which offers significant opportunities and challenges (Boston Consulting Group, 2021). The profitability and competitiveness of each play depend on several factors, such as customer preferences, cost structures, and partnerships. To succeed in this market, companies need to

understand the dynamics and trends of the EV ecosystem and position themselves accordingly (Bangkok Post, 2021).

2.6.3 Improvement of technologies and AI clusters

EV clusters can also benefit from the advancement of AI applications, which can improve the efficiency, performance, and customer experience of EVs. AI involves data-driven algorithms for reasoning, learning, and decision-making, while ML enables computers to make predictions without explicit programming. AI applications for EVs include smart charging, which can optimize the charging time, cost, and location based on user preferences, grid conditions, and weather forecasts; autonomous driving, which can enhance the safety, comfort, and convenience of EV users; predictive maintenance, which can monitor the health and performance of EV components and batteries and alert users of potential issues; and personalized services, which can tailor the EV features and settings to the user's needs and preferences (Yec, 2023).

2.6.4 Supply chain cluster

A supply chain cluster is a geographic concentration of actors involved in designing, manufacturing, distributing, and servicing electric vehicles (EVs) and their components. It can provide the necessary infrastructure, innovation, and policy support for the transition to low-carbon mobility. It can also help to achieve economies of scale, reduce costs, improve quality, enhance innovation, and increase customer satisfaction. Furthermore, it can help overcome the challenges and uncertainties associated with EV market demand and regulation and enhance the competitiveness and sustainability of the EV industry in the global market (Kalaitzi et al., 2019; IEA, 2022; PwC, 2019).

2.7 Chance

Technological Improvement: Advancements in battery technology are crucial. Battery improvements like increased range, faster charging times, and lower costs are making EVs more practical and appealing to consumers. Additionally, advancements in chargers and other EV components are improving efficiency and affordability. This progress, along with the potential to

integrate EVs with renewable energy sources and smart grid technologies, paints a bright future for sustainable transportation (Forbes, 2021).

2.7.1Policy support

Governments around the world are implementing policies that promote EV adoption. These include fiscal incentives like tax breaks and rebates, stricter emissions standards that encourage manufacturers to produce more EVs, sales targets that set goals for EV market share, investments in charging infrastructure to address range anxiety, and preferential access schemes that give EVs advantages like access to carpool lanes. These policies are having a significant impact on stimulating EV sales and market development (IWEF, 2022)..

2.7.2 Environmental imperative

Consumers and businesses are increasingly aware of the environmental benefits of EVs. EVs produce zero tailpipe emissions, which helps to improve air quality and combat climate change. Furthermore, they support the transition to a low-carbon energy system, a critical step towards a more sustainable future. This growing environmental consciousness is driving demand for EVs among both consumers and fleet operators (WRI, 2021)..

2.7.3 Innovation and the Future of EVs

The future of EVs is brimming with innovative applications powered by artificial intelligence (AI). These include smart charging systems that optimize charging based on electricity costs and grid demand, autonomous driving capabilities that promise a safer and more convenient driving experience, predictive maintenance that can identify potential problems before they occur, and even personalized services that cater to individual driver needs. These advancements hold the potential to further improve the efficiency, performance, and overall customer experience of electric vehicles. (WEF, 2022).

2.8 Government

The Thai government has been pursuing a vision of becoming an electric vehicle (EV) hub in Southeast Asia, as part of its strategy to promote green growth and reduce greenhouse gas

emissions from the transport sector. The government has adopted various policies and incentives to support the development and adoption of EVs, such as tax exemptions, subsidies, investment privileges, and infrastructure support. However, there are also challenges and barriers that may hinder the achievement of the government's EV targets, such as high costs, limited range, consumer preferences, and grid capacity constraints.

One of the main efforts of the Thai government is to provide tax exemptions and subsidies for EV consumers and producers. The government has reduced import duties and excise taxes on imported EVs, depending on the price range, until 2023 (electrive.com, 2022). The government has also offered subsidies for each EV car and motorcycle produced by eligible manufacturers. These measures are expected to stimulate the demand and supply of EVs in the country, as well as to reduce the cost gap between EVs and conventional vehicles (ITA, 2022).

Another effort of the Thai government is to provide investment privileges and incentives for EV industry players. The government has launched incentives for automakers, component suppliers, and other companies involved in the EV industry, such as tax exemptions, raw material privileges, and machinery import tariff reductions (ASEAN Briefing, 2022). The government has also slashed income tax rates for skilled foreign professionals in targeted industries. These measures are expected to attract more investment and innovation in the EV industry, as well as to enhance the competitiveness and quality of EV products and services (S&P Global, 2020).

A third effort of the Thai government is to provide infrastructure support for EV operation and integration. The government has set a target to build more charging stations in the country, with the help of state-owned enterprises such as PTT Plc and the Electricity Generating Authority of Thailand. The government has also planned to promote the integration of EVs with renewable energy sources and smart grid technologies, which can provide clean and cheap electricity for EV charging, as well as enable demand response, load management, and vehicle-to-grid services. These measures are expected to improve the convenience and reliability of EV charging, as well as to support the transition to a low-carbon energy system (KPMG Thailand, 2021).

Regulation and policies can drive innovation, such as research and development (R&D), collaboration and partnership, regulation and policy, consumer feedback and demand, and market competition and dynamics. However, innovation can also face various challenges, such as technical complexity and uncertainty, high costs and risks, regulatory barriers and gaps, consumer resistance

and inertia, and market fragmentation and saturation. Various measures can support and facilitate innovation, such as funding and incentives, standards and guidelines, testing and demonstration, education and training, and dissemination and diffusion. Innovation can help to achieve various goals, such as reducing greenhouse gas emissions and air pollution, improving energy security and efficiency, enhancing customer satisfaction and loyalty, and increasing market share and profitability (IEA, 2021).

2.9 Influencing Factors (Focus on Internal Factors)

Public awareness: Public awareness is the level of knowledge and information that consumers have about electric vehicles (EVs). It can affect the demand and supply of EVs, as well as the public acceptance and support for EV policies and incentives. Previous studies have suggested that public awareness can have both positive and negative effects on EV adoption, depending on the quality and quantity of the information provided (Abbott et al., 2021; Dans, 2021). Therefore, the EV industry and stakeholders need to manage public awareness carefully and strategically, by providing factual and relevant information, addressing consumer concerns and questions, using various channels and platforms to communicate, and collaborating with other actors to create a positive image and reputation for EVs.

Various strategies can be used to enhance public awareness, such as media campaigns, online platforms, social media networks, events, demonstrations, testimonials, and word-of-mouth. These strategies can help to increase the exposure and visibility of EVs, as well as to educate and persuade consumers about the benefits and advantages of EVs (IEA, 2021). However, public awareness can also be hindered by various barriers, such as information overload, confusion, uncertainty, skepticism, and resistance. These barriers can result from the complexity and diversity of EV technologies, products, and services, as well as from the misinformation and bias of some sources or actors.

2.9.1 Consumer preferences and demand

Consumer preferences are another important factor that affects the adoption of EVs. Consumer preferences refer to the attitudes, opinions, values, beliefs, and motivations that consumers have toward EVs. Consumer preferences can influence the decision-making process of

consumers when they choose between different types of vehicles or modes of transport. Consumer preferences can also shape the expectations and satisfaction of consumers with their EV experience. Dans (2021) argued that consumer preferences can be influenced by various factors, such as personal characteristics (e.g., age, gender, income, education, lifestyle), social influences (e.g., family, friends, peers, norms, culture), and situational factors (e.g., availability, accessibility, convenience, price, incentives).

Consumer preferences can be favorable or unfavorable for EV adoption, depending on the perceived value and attractiveness of EVs compared to other alternatives. Consumer preferences can also change over time and across contexts, depending on the learning and experience of consumers with EVs. Various methods can be used to understand and influence consumer preferences, such as market research, analysis, segmentation, targeting, positioning, differentiation, persuasion, and feedback. These methods can help to identify and meet the needs, wants, and expectations of consumers, as well as to provide value propositions and competitive advantages for EVs (WEF, 2022).

2.9.2 Innovation in other clusters

Innovation is a key factor that drives the adoption of EVs. Innovation refers to the process of creating, developing, and implementing new or improved products, services, processes, or business models in the EV industry. Innovation can involve various aspects of the EV value chain, such as vehicle design, battery technology, charging infrastructure, software applications, and mobility services. Innovation can enhance the performance, efficiency, safety, convenience, and affordability of EVs, as well as create new value propositions and competitive advantages for EVs. Biliti Electric (2021) reported some of the recent innovations in EV technology, such as AI algorithms for EV charging management, innovative battery management, electrified roads, automatic battery heating, and incredibly quick charging.

2.9.3 Market development

Market development is the process of expanding the potential market for EVs by using various strategies, such as entering new regions or segments, creating new product categories or niches, diversifying product offerings or features, and increasing product usage or frequency.

Market development can increase the demand and supply of EVs, as well as the awareness and acceptance of EVs. However, market development can also face various challenges, such as market uncertainty and volatility, market complexity and diversity, market regulation and compliance, market resistance and competition, and market saturation and cannibalization. (“Global EV Outlook 2021 – Analysis - IEA,” 2022)

CHAPTER 3

Methodology

3.1 Research Design

This study will use a documentary methodology and the diamond framework to explore the multifaceted effects of electric vehicle (EV) integration on Thailand's automobile manufacturing cluster and conducted from May 2023 to April 2024. By analyzing existing research, statistics, and market reports, the study aims to understand the complete picture of how EVs are affecting the automotive industry. Additionally, the research will delve into the social and regulatory challenges associated with this transition, including potential impacts on society, difficulties with new regulations, and concerns about data accuracy

3.2 Data Collection

To comprehensively understand the impact of electric vehicles (EVs) on Thailand's automobile manufacturing cluster, this research will employ a multi-pronged data collection approach:

- Literature Review: An extensive review of academic journals, industry reports, and scholarly articles will be conducted to gain insights into existing research, trends, and challenges surrounding EV integration within the Thai automotive sector.
- Statistical Analysis: Statistical data from reputable sources will be analyzed to assess economic trends, market growth within the Thai auto industry, and the specific impact of EV adoption on this cluster.
- Market Research Report Review: Market research reports focusing on EV adoption in Thailand, the dynamics of the Thai automotive market, and the broader societal, regulatory, and technological implications of this shift will be scrutinized.

3.3 Content Analysis

This chapter summarizes the content used to investigate the influence of electric vehicle developments on the automobile manufacturing cluster. The content analysis is used to examine the impact of electric vehicles (EVs) on Thailand's auto manufacturing sector. This analysis involves identifying central themes and trends from the data, along with the key factors influencing this

transition, such as government policies, consumer preferences, and technological advancements. The research will synthesize these themes and factors with their corresponding sources and references, creating a transparent and verifiable picture of the economic, social, and regulatory implications of EV adoption on Thailand's automotive industry. As a result, the following table provides a comprehensive framework for understanding of this paper.

Keywords	Influencing Factors	Findings/Sources/References
Impact of Electric Vehicle	Technology	(Forbes, 2021; WEF, 2022)
	Environment	(WRI, 2021; IEA, 2021)
	Market development	("Global EV Outlook 2021 – Analysis - IEA," n.d.)
Electric vehicle cluster	Supply chain	(Kalaitzi et al., 2019; IEA, 2022; PwC, 2019)
	Consumer demand	(WEF, 2022)
	Innovation	Biliti Electric (2021)
Thailand	investment privileges and incentives	(ASEAN Briefing, 2022; S&P Global, 2020)
	Vehicle regulation and policies	(IEA, 2021)
	infrastructure support for EV	(electrive.com, 2022; KPMG Thailand, 2021)

Table 2 – Content Analysis of Automobile Cluster

Chapter 4

Findings

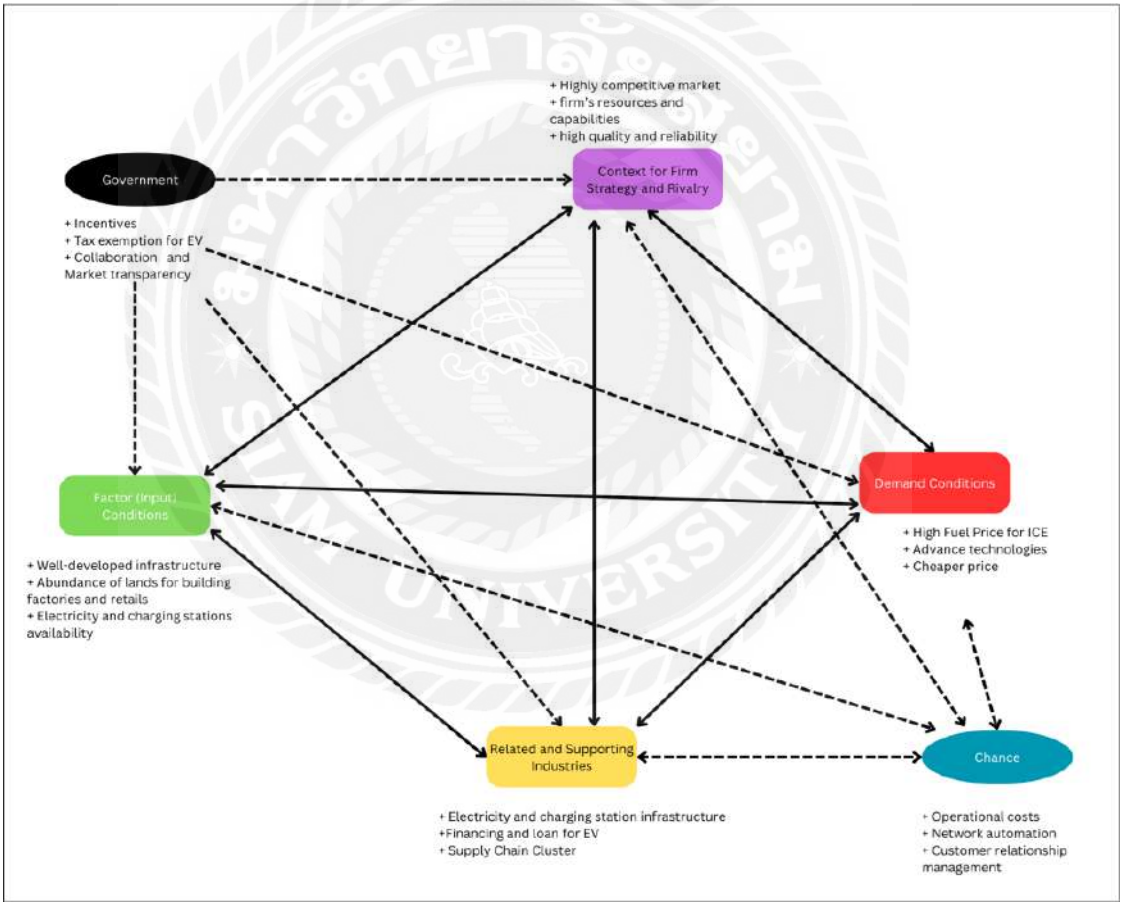
4.1 Factor (Input) Conditions

The Porter's Diamond Model, a theory of national competitive advantage, offers valuable insights into the impact of electric vehicles (EVs) on Thailand's automobile manufacturing cluster. This framework highlights several key factors that influence Thailand's competitiveness in this emerging space. The model emphasizes the importance of government support. Policies like tax breaks, subsidies for EV production and charging infrastructure development, and investments in research and development can significantly influence Thailand's EV industry growth. Demand conditions also play a crucial role. Consumer preferences for EVs, fuel efficiency standards, and the overall growth of the domestic and export markets for EVs will all shape Thailand's EV demand landscape. A robust ecosystem of related and supporting industries is essential. This includes battery production, charging infrastructure development, and the manufacture of electric vehicle components. Factor conditions refer to the availability of a skilled workforce with expertise in EV technology, along with research institutions and universities that can drive innovation within the sector. By addressing these factors and fostering collaboration among stakeholders, Thailand can position itself as a leader in the transition to electric vehicles. The Porter's Diamond Model, therefore, provides a valuable framework for understanding Thailand's competitive advantage in the EV sector.

Thailand's potential for electric vehicle (EV) manufacturing hinges on several key input conditions. A skilled workforce with expertise in automotive engineering and related fields like battery technology is crucial for efficient production and innovation. Universities and research institutions play a vital role in developing this talent pool and fostering a culture of research and development (R&D) in the EV sector (Alanazi, 2023). Furthermore, the presence of a robust supply chain for EV components is essential. This includes local capabilities in manufacturing electric motors, battery management systems, and other critical components. A strong domestic supply chain can reduce reliance on imports, potentially lowering production costs and enhancing Thailand's competitiveness in the global EV market. Thailand's existing infrastructure, particularly its well-developed automotive manufacturing base, provides a strong foundation for the transition

to EVs. Existing production facilities and skilled labor in the traditional auto industry can be leveraged and adapted to meet the demands of EV production. However, investments in upskilling the workforce and adapting production lines will be necessary to ensure a smooth transition. In conclusion, Thailand's existing pool of skilled labor, the potential for R&D development, and its established automotive manufacturing infrastructure all represent key input conditions that can propel the country's growth in the EV sector ((“Board of Investment of Thailand,” 2023).

Figure 2 – Impact of electric vehicles trend on automobile manufacturing cluster in Thailand



Diamond Analysis

4.2 Demand Conditions

The demand conditions within Thailand's Electric Vehicle (EV) landscape depict a strong increase in adoption and reliance on Electric Vehicles. Remarkably, the sector saw a significant revenue increase, with the market projected to reach a revenue of US$1,103.0m in 2024. This rapid growth reflects the crucial role EVs play in the automotive industry, supported by the fact that Thailand is rapidly emerging as a key player in the electric vehicle market. The statistics further highlight this reliance, with a projected market volume of US$1,344.0m by 2028. Such widespread adoption demonstrates EV's crucial contribution to enhancing efficiency and catering to diverse transportation needs, reflecting a growing interest and necessity for these vehicles in the evolving market landscape. The Thai government has big plans for electric vehicles (EVs). They want all EVs sold in the country by 2035 to be made in Thailand. They're expecting to sell 27.32k EVs by 2028. The average price of an EV in Thailand is expected to be US$50.5k in 2024. When compared to other countries, China is expected to make the most money from EVs, with revenues of US$319,000m in 2024. Thailand is quickly becoming a big player in the EV market, thanks to government support and a growing network of charging stations. By the third quarter of 2022, 60% of all EVs sold in the region were in Thailand, a 35% increase from the previous year. This shows that the EV market in Thailand is growing fast. The government's support and the increasing use of EVs are driving this growth. The future of the EV market in Thailand looks bright, with sales and revenue expected to increase (Statista, 2024).

4.3 Context for Firm Strategy and Rivalry

In the highly competitive landscape of the Electric Vehicle (EV) market within Thailand, numerous companies vigorously compete for market dominance and customer attention. This dynamic arena encompasses established automotive giants, burgeoning startups, and specialized niche providers, all engaged in an intense rivalry driven by a spectrum of factors. These include the array of vehicle features, pricing models, quality of customer support, and scalability capabilities. To establish distinct market positions and gain an edge, these EV entities employ varied strategies, with product differentiation being a prevalent tactic. This involves offering unique features, customization options, and seamless integrations with other automotive technologies. Simultaneously, these companies prioritize cultivating trust and loyalty among their customer base

by delivering dependable vehicles, responsive customer support, and fostering a positive brand image (Nationthailand, 2023).

In the pursuit of market leadership, EV clusters consistently innovate, often leveraging advanced technologies to propel advancements in vehicle performance, automation, and personalized user experiences. The strategic integration of these technologies, such as AI-driven autonomous driving and advanced battery technologies, into their product lines enables these companies to bolster their offerings and stay ahead in a rapidly evolving and competitive landscape. The rising adoption of advanced technologies in EVs is evident, with substantial investments in R&D to harness its potential, expected to elevate the global EV market revenue to US$1,103.0m by 2024. Notably, Thailand is rapidly emerging as a key player in the electric vehicle market, with government incentives and a growing charging infrastructure driving significant adoption. The integration of advanced technologies takes various forms, from facilitating predictive analytics through machine learning algorithms driven by extensive data to deploying advanced battery technologies, enabling improved range and performance within EV frameworks (Thailand, 2023).

4.4 Related and Supporting Industries for Electric Vehicles in Thailand

Thailand's ambitious electric vehicle (EV) industry thrives on a network of interconnected and critical supporting industries. These industries contribute significantly by providing essential components, expertise, and infrastructure that underpin a robust EV ecosystem.

One prominent supporting industry is Thailand's established automotive supply chain. This sector boasts over 1,700 companies in upstream industries and a network of 1,820 auto parts suppliers, encompassing expertise in everything from traditional car parts (plastics, rubber) to electronics and safety systems (SET, 2023). This existing infrastructure can be readily adapted to EV production, minimizing the need for significant investments in entirely new manufacturing capabilities (KPMG, 2021). This established supply chain offers a significant advantage for Thailand's EV industry, allowing for quicker and more cost-effective production compared to starting from scratch.

The electronics industry also plays a vital role. Thailand has a strong presence of established electronics manufacturers like Delta Electronics, renowned for their expertise in power management, onboard chargers, and other crucial EV components (Kompas.id, 2024). This domestic electronic manufacturing capability not only reduces reliance on foreign imports but also

fosters the development of homegrown technological advancements specific to EVs. The synergy between the existing automotive supply chain, a growing electronics sector, and government support creates a fertile ground for Thailand's aspirations to become a major player in the global EV market.

Furthermore, the Thai government actively fosters the development of new industries crucial for EVs. The Board of Investment (BOI) offers attractive investment incentives for companies involved in battery production, charging infrastructure development, and other EV-related sectors (BOI, 2023). These incentives not only attract foreign expertise but also encourage domestic companies to venture into these new areas, creating a dynamic and self-sustaining EV ecosystem. This government support strengthens the entire EV industry by promoting innovation and investment across the value chain.

4.5 Government

Thailand's government is mirroring the US focus on data governance with an aggressive push for electric vehicles (EVs). Their comprehensive policy framework, overseen by the National Electric Vehicle Policy Committee, resembles the role of a Chief Data Officer. This "EV 3.5" scheme offers subsidies and tax breaks to reduce upfront costs for consumers, similar to how open data initiatives improve accessibility. Additionally, the government incentivizes local production by exempting import duties on both EVs and crucial parts, mirroring how the US might invest in data infrastructure. This ambitious plan aims to position Thailand as a leading EV hub in Asia, capitalizing on its existing strengths in auto manufacturing and seeking to create a future-proof industry (Thai EV Businesses to Secure THB227 BN Investments, 2024).

In February 2022, the Thai government significantly bolstered its EV industry incentives. This move aligns with their plan to transform half of their total auto production to EVs by 2030. The incentives include tax and duty reductions. The government offers reduced import duties for electric vehicles brought in for market testing, with the exact rate depending on Free Trade Agreements (FTAs). Additionally, excise tax reductions from 8% to 2% for electric passenger cars and complete exemption for electric pickup trucks are pending regulations.

EV adoption in Thailand has seen a substantial increase across categories since 2020. By September 2023, electric passenger vehicles reached a 10% adoption rate, demonstrating a growing consumer interest. However, the Thai EV market still faces challenges. These include a need for a

more comprehensive EV policy framework, overcoming regulatory hurdles, expanding charging infrastructure nationwide, attracting higher investment in the industry, addressing the initial cost barrier for consumers, and potentially increasing government support.

The Thai government remains committed to its EV goals. They aim to reach 30% EV production of their total annual car production by 2030. Additionally, a three-year car and motorcycle trade-in scheme is planned to further encourage adoption. Research efforts are also ongoing to understand the current state of charging infrastructure, available EV options, and the various charging services offered. By addressing challenges and implementing these plans, Thailand has the potential to become a major player in the global EV landscape (Thailand's Big Push into the Electric Vehicle Market (SEADS, 2024).

4.6 Chance

The electric vehicle (EV) market in Thailand is poised for significant growth. The Thai government is actively promoting EV adoption through ambitious targets and financial incentives, aiming for half of all new vehicles to be electric by 2030 and complete electrification by 2035. This policy shift reflects a growing consumer interest in EVs, as evidenced by the recent surge in sales. Furthermore, Thailand aspires to become a Southeast Asian EV production hub, attracting investment from major car manufacturers (KPMG, 2021). This domestic production could drive down costs and increase accessibility of EVs for Thai consumers. Thailand's transportation sector is undergoing a significant transformation with the rise of electric vehicles (EVs). Driven by a confluence of environmental concerns, government initiatives, and consumer demand for sustainable solutions, EVs present a wealth of opportunities for the nation's economy and environment.

4.6.1 Environmental Benefits and Public Health

The transition to EVs aligns perfectly with Thailand's ambitious goals of lowering carbon emissions and air pollution. This not only benefits the environment by mitigating climate change (IPCC, 2022) but also fosters public health by reducing respiratory illnesses and other health problems associated with air pollution (World Health Organization, 2019). Cleaner air, particularly in urban centers, will improve the overall quality of life for Thai citizens. Additionally, Thailand's

image as a progressive nation committed to sustainability can be strengthened, potentially attracting environmentally conscious tourists (UNWTO, 2023).

4.6.2 Economic Growth and Job Creation

Thailand's established automotive industry, a cornerstone of its economy, positions it strategically to become a leading EV production hub in Southeast Asia. Local production of EVs and their components can attract foreign investment and create high-skilled jobs across various sectors, including engineering, manufacturing, and research & development (Asian Development Bank, 2024). Furthermore, the burgeoning EV ecosystem necessitates a robust supply chain for batteries, charging infrastructure, and other components. This presents a golden opportunity for Thai businesses to establish themselves as key players in the EV supply chain, fostering domestic economic growth. The EV revolution also paves the way for innovative business models like battery leasing, car-sharing services with EVs, and green financing solutions, encouraging entrepreneurship and creating new avenues for economic prosperity.

4.6.3 Enhanced Energy Security

Thailand's dependence on imported oil can be significantly curbed by transitioning to EVs. This not only lessens the country's vulnerability to price fluctuations in the global oil market but also strengthens its energy security. The integration of EVs with the power grid can pave the way for the adoption of smart grid technologies, enabling efficient charging during off-peak hours and potentially utilizing renewable energy sources to power EVs (KPMG International, 2021). Furthermore, increased demand for electricity to power EVs can incentivize investments in renewable energy sources like solar and wind power, promoting domestic energy production and reducing reliance on fossil fuels.

By capitalizing on these multifaceted opportunities, Thailand can position itself as a frontrunner in the global EV revolution, reaping significant economic and environmental benefits for the nation and its people.

However, challenges remain. The charging infrastructure in Thailand is still limited, potentially deterring potential EV buyers due to "range anxiety" – the fear of running out of power before reaching a charging station (Krungsri Research, 2023). Additionally, despite government

incentives, EVs generally have a higher upfront cost compared to gasoline vehicles. Overcoming these limitations will be crucial for Thailand to achieve its ambitious EV goals.

Chapter 5

Conclusion and Recommendation

5.1 Conclusion

Thailand's Electric Vehicle (EV) cluster is revving up for a major leap forward. Government initiatives and a dedication to technological innovation are supercharging this sector, priming it to become a regional leader. Supportive policies, infrastructure investments, and a strong manufacturing base are the fuel in this engine of growth. However, the industry's success depends on continued government support, a culture of innovation, a skilled workforce development plan, and embracing sustainable practices. By addressing these factors, Thailand can ensure it stays in the pole position of the global shift towards electric mobility. In the first half of 2022, renewable energy provider Energy Absolute claimed 47.5 percent market share of electric vehicle charging stations in Thailand under its EA ANYWHERE brand. This was followed by EV Station (by EVLOMO in partnership with PTT) with a market share of 13.1 percent, trailed by Evolt with 11.6 percent of total market share. As of September 2023, the number of electric buses in Thailand amounted to around 2.36 thousand units. Meanwhile, the number of electric trucks in the country reached about 0.27 thousand units in that same year (Statista, 2022a). Electric vehicle sales in Thailand surged in 2023, with a whopping 684% increase compared to 2022. This significant growth indicates a growing popularity of electric vehicles in the country. In 2023, electric vehicles accounted for 12% of the total vehicles registered in Thailand, with a total of 78,314 units sold. Chinese electric vehicle makers were the leaders in sales, with BYD, Neta, and MG topping the list. Tesla followed closely behind as the fourth-highest selling brand (Electric Vehicle Sales Surged in Thailand in 2023, 2024).

AI is supercharging Electric Vehicle (EV) growth. AI optimizes charging networks, reducing wait times and managing grid loads. It also personalizes the EV experience with apps that track battery health, recommend charging based on habits, and locate stations. Data security and a skilled workforce are key challenges, but by addressing these, AI can propel the EV industry forward and create a more sustainable transportation future Pathe (2023).

The transportation sector is a significant contributor to global carbon emissions, accounting for roughly 23% in 2020 according to the International Energy Agency (IEA, 2023). This has spurred a growing interest in electric vehicles (EVs) as a potential solution for mitigating greenhouse

gas emissions. Unlike internal combustion engine (ICE) vehicles, EVs produce zero tailpipe emissions, offering a clear advantage in terms of air quality and climate change concerns. Studies have shown that EVs can achieve life-cycle emissions reductions of 40-80% compared to gasoline vehicles, depending on the electricity grid mix (Rashid & Pagone, 2023). This significant reduction in emissions is driving the rapid growth of the EV market, with global sales expected to reach 30 million by 2030 (IEA, 2023). As the electricity grid transitions towards cleaner sources like solar and wind power, the environmental benefits of EVs are expected to further increase, solidifying their role in a sustainable transportation future (Global EV Outlook 2022 – Analysis - IEA, 2022). Even though there are great opportunities, there are also challenges like disassembling the used batteries of electric vehicles, building new net zero energy infrastructure, competition the market share with ICE vehicles is still consideration.

Thailand's electric vehicle (EV) industry is experiencing a period of exceptional growth, fueled by government initiatives, technological innovation, and a strong manufacturing base. This surge is further bolstered by the environmental benefits of EVs, which contribute significantly to reducing greenhouse gas emissions and mitigating climate change. However, for Thailand to solidify its position as a regional leader in the EV sector, it must continue to prioritize several key areas. Sustained government support, a culture of continuous innovation, and a skilled workforce development plan are all crucial. Additionally, embracing sustainable practices throughout the EV lifecycle, from battery production to end-of-life management, will be essential. By addressing these critical factors and capitalizing on its existing strengths, Thailand has the potential to become a global frontrunner in the electric mobility revolution. The country's success in this endeavor will not only benefit its own economy and environment but will also serve as a model for other nations seeking to transition toward a more sustainable transportation future. Looking ahead, traditional internal combustion engine (ICE) car manufacturers in Thailand, and around the world, must adapt to this rapidly changing landscape. This can be achieved by investing in EV research and development, upskilling their workforce, and potentially even exploring partnerships or mergers with established EV companies.

5.2 Recommendation

5.2.1 Challenges in Electric Vehicle Adoption Readiness in Thailand's automobile manufacturing clusters

Electric vehicles (EVs) are seen as a promising solution for sustainable transportation in Thailand, as they can offer various benefits such as reducing fossil fuel dependency, greenhouse gas emissions, and air pollution. However, the adoption rate of EVs in some regions of Thailand is still very low, and there are many challenges that need to be overcome. Some of the main challenges are the lack of technological innovation and development, the insufficient and inadequate charging infrastructure, the high cost and low availability of EVs and batteries, the unfavorable regulations and policies, and the low consumer awareness and preference. To address these challenges, the authors of the articles suggest some public policy recommendations, such as providing incentives and subsidies for EV manufacturers and consumers, developing and expanding the charging network, supporting research and development of EV technologies, creating standards and regulations for EV safety and performance, and promoting education and awareness campaigns for EV benefits. By implementing these recommendations, Thailand can enhance its readiness for EV adoption and achieve its goals of sustainable transportation (Preedakorn, Butler, & Mehnen, 2023).

The transportation sector is a significant contributor to air pollution and greenhouse gas (GHG) emissions in Thailand. Electric vehicles (EVs) offer a promising solution, promoting cleaner and more sustainable mobility. However, despite Thailand boasting a robust automobile manufacturing industry, the adoption rate of EVs in certain regions remains low. This paper explores the key challenges hindering Thailand's EV adoption and proposes potential solutions to overcome them.

5.2.2 Technological Hurdles

One major challenge lies in the lack of domestic technological innovation and development related to EVs. Thailand's existing automotive industry largely relies on established internal combustion engine (ICE) technologies. A study by the Thailand Development Research Institute (TDRI, 2023) highlights the limited research and development (R&D) capabilities in areas crucial for EVs, such as battery technology, electric powertrains, and advanced materials. This dependence

on foreign technology hinders Thailand's ability to compete in the global EV market and restricts its potential for long-term growth in the sector.

5.2.3 Infrastructure Bottlenecks

Another significant challenge is the inadequacy of Thailand's charging infrastructure. The current network of charging stations is limited, particularly outside major urban centers. This creates "range anxiety" among potential EV buyers, who fear running out of power before reaching a charging station. A report by the Energy Policy and Planning Office (EPPO, 2023) emphasizes the need for a nationwide expansion of charging infrastructure, focusing on both public and private charging options. Additionally, integrating renewable energy sources into the charging network would further enhance the environmental benefits of EVs.

5.2.4 Cost Concerns and Market Dynamics

The high upfront cost of EVs compared to traditional ICE vehicles remains a significant barrier to adoption. This price disparity is largely due to the high cost of lithium-ion batteries, a crucial component of EVs. Furthermore, the limited availability of EVs in the Thai market restricts consumer choice and can potentially inflate prices due to a lack of competition. Studies by the National Bureau of Economic Research (NBER, 2023) suggest that government subsidies and tax breaks for EV manufacturers and consumers could help bridge the price gap and stimulate demand.

5.2.5 Policy and Regulatory Landscape

Unfavorable regulations and policies can also hinder EV adoption. Complex bureaucratic procedures for EV registration and unclear regulations surrounding battery recycling can discourage potential buyers and investors. Additionally, a lack of standardized safety regulations specific to EVs can create uncertainty for manufacturers and consumers. The Ministry of Transport (MoT, 2023) could address these issues by streamlining registration processes, introducing clear and consistent policies for battery disposal and recycling, and developing comprehensive safety standards for EVs.

5.2.6 Consumer Awareness and Preference

Low consumer awareness regarding the benefits of EVs and potential range limitations compared to ICE vehicles can also impede adoption. Additionally, a lack of understanding about the environmental advantages and long-term cost savings associated with EVs can further dissuade potential buyers. The Electricity Generating Authority of Thailand (EGAT, 2023) recommends implementing public education and awareness campaigns to highlight the environmental and economic benefits of EV ownership. These campaigns could also address concerns about charging infrastructure and range limitations.

5.3 Strategies for automobile manufactures to adapt to the impact of the electric vehicle trend

Electric vehicles (EVs) are a solution for sustainable transportation, as they can reduce fossil fuel consumption, greenhouse gas emissions, and the negative impacts of climate change and global warming, as well as help improve air quality. However, EV adoption in Thailand is quite low compared to other countries, and there are many barriers and challenges that need to be overcome. Therefore, this paper recommends the following research actions to promote the environmental benefits of EVs and increase consumer awareness and preference in Thailand.

Firstly, understanding consumer behavior and preferences is crucial. A comprehensive literature review can provide valuable insights into successful EV outreach strategies implemented in other regions. Studies by Kwan et al. (2016) and Sanguesa et al. (2021) highlight the effectiveness of providing information and educational tools, organizing events and workshops, and increasing consumer exposure to EVs through carsharing and fleet programs. These findings can inform the development of targeted marketing campaigns and public awareness initiatives tailored to the Thai market.

Secondly, conducting surveys of potential and current EV users in Thailand can offer a deeper understanding of their concerns, preferences, and motivations for adoption. Research by Kongklaew et al. (2021) suggests that young drivers with more than five years of experience (26-35 years old) may be a key target segment for early EV adoption. By identifying such target groups, policymakers and industry leaders can develop strategies that address specific concerns and incentivize purchase decisions.

Thirdly, evaluating the effectiveness of existing government policies is essential. Studies like that by Preedakorn et al. (2023) explore the impact of public policy measures such as subsidies for manufacturers and consumers, charging infrastructure expansion, R&D support for EV technologies, safety regulations, and educational campaigns. By analyzing the effectiveness of these initiatives, policymakers can refine and optimize existing strategies or introduce new ones to address critical gaps.

Finally, a life-cycle assessment comparing the environmental impact of EVs, and conventional vehicles is crucial (S&P Global Market Intelligence, n.d.). Evaluating factors like energy consumption, resource use, greenhouse gas emissions, and waste generation can provide clear data on the environmental benefits of EV adoption in Thailand. This data can then be used to inform public outreach campaigns and policy decisions, further promoting the environmental advantages of EVs.

By implementing a combination of these strategies, Thailand's automobile manufacturing cluster can adapt to the evolving automotive landscape. Understanding consumer behavior, evaluating existing policies, and highlighting the environmental benefits of EVs will be key to overcoming adoption hurdles and ensuring Thailand's position as a regional leader in the electric vehicle revolution.

5.4 Discussion and Implications

The adoption of electric vehicles (EVs) within Thailand’s automotive sector presents a unique set of challenges that must be addressed to ensure sustained growth and competitiveness. One of the primary obstacles lies in the country’s reliance on established internal combustion engine (ICE) technologies, which are deeply ingrained within the existing automotive industry. This reliance has resulted in a lack of domestic technological innovation and development related to EVs, particularly in areas such as battery technology, electric powertrains, and advanced materials.

5.4.1 Research Contribution

A study by the Thailand Development Research Institute (TDRI, 2022) underscores this issue, highlighting the country’s limited research and development (R&D) capabilities in these

crucial areas. This dependence on foreign technology not only hinders Thailand's ability to compete in the global EV market but also restricts its potential for long-term growth within the sector.

To overcome these challenges, the study recommends two key strategies. The first involves establishing robust data governance and privacy measures through a privacy-by-design approach and continuous security testing. This strategy necessitates the fostering of a strong DevSecOps culture within the industry and the implementation of comprehensive security measures to ensure the secure handling of user data.

The second strategy emphasizes the importance of adopting a customer-centric development approach. This involves gathering extensive customer feedback and understanding user needs to ensure that AI-powered SaaS offerings effectively address user requirements, thereby contributing to enhanced user satisfaction. By implementing these strategies, Thailand can position itself as a leader in the global EV market and pave the way for a sustainable future.

5.4.2 Contribution to the Thai Economy

Electric vehicles (EVs) hold immense potential to propel the Thai economy forward. This section meticulously examines how EVs can generate economic activity across various sectors, fostering growth and sustainability.

Reduced Reliance on Fossil Fuels: Thailand's dependence on imported oil exposes its economy to volatile global oil prices. Widespread adoption of EVs can significantly reduce this dependence, leading to a more stable and secure energy landscape. This translates to cost savings for consumers and businesses, while also freeing up resources for investment in other sectors.

Growth of Domestic Manufacturing: The rise of EVs presents a golden opportunity to develop a robust domestic EV manufacturing industry. Government initiatives to attract foreign investment and establish local production hubs can create a thriving ecosystem of EV manufacturers, parts suppliers, and service providers. This will not only create high-skilled jobs but also position Thailand as a regional leader in the EV industry.

Boost to Infrastructure Development: The transition to EVs necessitates investments in charging infrastructure. This creates opportunities for businesses to develop and maintain charging stations across the country. Additionally, the government can leverage this shift to modernize the

national grid, integrating renewable energy sources to power charging stations, fostering a cleaner and more sustainable transportation system.

Environmental Benefits: By curbing air and noise pollution from traditional vehicles, EVs can significantly improve Thailand's environmental profile. This not only enhances public health and quality of life but also strengthens Thailand's position as a responsible and environmentally conscious nation, potentially attracting eco-conscious tourists and businesses.

In conclusion, the adoption of electric vehicles presents a multifaceted opportunity for Thailand's economic growth. From reduced dependence on imported oil to the rise of a domestic EV industry, EVs offer a path towards a more secure, sustainable, and prosperous future for Thailand.

5.4.3 Contribution to Various Industries

The rise of electric vehicles (EVs) extends far beyond the transportation sector, creating a ripple effect that positively impacts numerous industries. Here's a breakdown of how EVs can revitalize various sectors:

Energy Sector: Increased Electricity Demand: EV charging will significantly increase electricity demand, prompting investment in renewable energy sources like solar and wind power. This shift towards clean energy production benefits utility companies and fosters a more sustainable energy grid.

Demand Management Opportunities: Charging EVs can be strategically scheduled to utilize off-peak hours, reducing strain on the grid during peak times. This empowers utility companies to implement dynamic pricing models, offering incentives for off-peak charging and encouraging smarter energy consumption.

Manufacturing Sector: Growth of New Industries: The EV revolution necessitates the development and production of various components like batteries, electric motors, and charging stations. This creates new industries, stimulates job creation, and positions countries at the forefront of this technological shift.

Supply Chain Transformation: Traditional auto manufacturers may need to adapt their production lines and forge new partnerships with battery and electric motor suppliers. This transformation fosters innovation and strengthens domestic supply chains.

Mining and Material Sector: Demand for Raw Materials: EV battery production relies on specific minerals like lithium and cobalt. This increased demand can benefit countries with rich deposits of these resources, boosting their economies.

Sustainable Practices: The potential environmental impact of mining these materials necessitates stricter regulations and investments in sustainable mining practices to minimize environmental damage.

Real Estate Sector: Demand for Charging Infrastructure: Residential and commercial properties with EV charging facilities become more attractive to tenants and buyers. This incentivizes real estate developers to integrate charging infrastructure into new projects.

Urban Planning Opportunities: Cities can leverage the transition to EVs to create designated electric vehicle zones with convenient charging stations. This fosters a more sustainable and integrated transportation system within urban areas.

Tourism Industry Eco-Friendly Travel Options: The availability of electric rental cars and charging stations caters to tourists seeking eco-friendly travel options. This positions destinations that embrace EVs as attractive choices for environmentally conscious travelers.

In conclusion, the electric vehicle revolution transcends the transportation sector, acting as a catalyst for growth and innovation across a diverse range of industries. From bolstering the energy sector with clean energy sources to creating new job opportunities in manufacturing, EVs have the potential to reshape the economic landscape for a more sustainable future.

5.5 Future Research Guidelines

The rise of electric vehicles (EVs) presents a significant transformation for the global automotive industry, and Thailand's established automobile manufacturing cluster is no exception. This research guideline outlines key areas to explore the impact of EVs on Thailand's automotive sector.

5.5.1 Production and Supply Chain Shifts

Skill Gaps and Workforce Development: Analyze the skills required for EV production compared to traditional vehicles. Identify potential skill gaps and explore strategies for workforce development to bridge these gaps.

Supply Chain Reorganization: Examine how the transition to EVs affects existing supply chains for components like engines, transmissions, and exhaust systems. Identify opportunities for Thai companies to adapt and integrate new EV-specific components into their production lines.

Foreign Direct Investment (FDI) and Technology Transfer: Analyze the potential impact of EVs on FDI in Thailand's automotive sector. Explore how to attract investments from established EV manufacturers and facilitate technology transfer to bolster domestic EV production capabilities.

5.5.2 Government Policy and Regulations

EV Incentives and Subsidies: Evaluate the effectiveness of current government incentives for EV production and purchase. Explore policy options that can further encourage investment in EV manufacturing and stimulate consumer demand for EVs.

Charging Infrastructure Development: Analyze the current state of Thailand's EV charging infrastructure and identify gaps in accessibility and coverage. Recommend strategies for promoting the development of a robust and nationwide charging network.

Battery Recycling and Sustainability Practices: Investigate potential environmental concerns associated with EV battery production and disposal. Recommend policy frameworks that promote sustainable battery life cycles, including recycling and responsible disposal practices.

5.5.3 Consumer Adoption and Market Trends

Consumer Preferences and Behavior: Conduct surveys and market research to understand Thai consumer attitudes towards EVs. Identify factors influencing purchase decisions, such as price, range anxiety, charging infrastructure availability, and brand preferences.

Impact on Traditional Vehicle Segments: Analyze how the rise of EVs might impact demand for traditional gasoline and diesel-powered vehicles within different market segments (e.g., sedans, SUVs, pickup trucks).

The Role of Public Transportation: Explore how the integration of EVs can complement and enhance existing public transportation systems in Thailand, fostering a more sustainable and integrated transportation network.

5.5.4 Regional and Global Dynamics

Competition in the Southeast Asian Market: Analyze Thailand's position within the Southeast Asian region in terms of EV production and adoption. Identify emerging competitors and potential opportunities for collaboration or regional specialization.

Global EV Trends and Technological Advancements: Monitor the latest advancements in EV technology and battery development on a global scale. Assess the potential impact of these advancements on Thailand's EV manufacturing capabilities and competitiveness.

Free Trade Agreements and Trade Policies: Analyze how existing free trade agreements and potential changes in trade policies might influence the import/export of EVs and EV components, impacting Thailand's position in the global EV market.

Additional Considerations should be conduct case studies of successful EV manufacturing clusters in other countries to identify best practices and lessons learned for Thailand. Integrate environmental impact assessments into the research, evaluating the potential reduction in greenhouse gas emissions and air pollution achieved through widespread EV adoption. Utilize econometric modeling to quantify the economic impact of EVs on Thailand's GDP, employment rates, and export potential. By exploring these key areas, researchers can gain a comprehensive understanding of the multifaceted impact of EVs on Thailand's automobile manufacturing cluster. This knowledge can inform policy decisions, industry strategies, and future investments to ensure a smooth transition towards a sustainable and thriving EV ecosystem in Thailand.

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