

Effect of Price, Operational Costs, and Electric Vehicle Infrastructure on Conventional Car Sales under Environmental Awareness Moderation: Case Toyota Brand in Indonesia

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Abstract

This study investigates the influence of electric vehicle (EV) price, operational costs, and supporting infrastructure on the declining sales of conventional Toyota vehicles in Indonesia, with environmental awareness as a moderating factor. The research is grounded in the accelerating global shift from fossil-fuelled transportation towards sustainable mobility, a transition that is reshaping consumer preferences and competitive dynamics in the automotive industry. Using a quantitative design and the Structural Equation Modelling–Partial Least Squares (SEM-PLS) method, data were collected from 250 respondents comprising owners of both electric and conventional vehicles across various regions of Indonesia. Findings reveal that EV price, operational costs, and infrastructure exert a significant impact on conventional vehicle sales, with the effect being amplified when environmental awareness is high. These results highlight that adoption is not solely driven by economic considerations but also by environmental values aligned with Sustainable Development Goal 13: Climate Action. For PT Toyota Sales Operation, the implications are clear: accelerating EV adoption and expanding the Battery Electric Vehicle portfolio are critical to sustaining market competitiveness. This research contributes to the discourse on green supply chain strategy and environmentally responsible innovation in emerging automotive markets.

Keywords: Electric Vehicle Price; Operational Costs; EV Infrastructure; Conventional Car Sales; Environmental Awareness; Toyota; Sustainable Development Goals; SEM-PLS.

1. Introduction

The automotive sector is currently experiencing a significant paradigm shift, driven by technological advancements and growing environmental awareness. The transition from internal combustion engine (ICE) vehicles to electric vehicles (EVs) is no longer a distant vision but a pressing necessity to address climate change. Globally, road transportation accounts for the majority of CO₂ emissions within the transport sector, with estimates from the International Energy Agency (IEA, 2023) indicating that road vehicles contribute almost 90% of transport-related emissions. In Indonesia, the transportation sector is responsible for approximately 23.14% of the nation's total greenhouse gas (GHG) emissions, the vast majority originating from road-based vehicles (Padhilah et al., 2023).

To address these environmental challenges, the Indonesian government has set ambitious targets, including the production of 600,000 battery electric vehicles (BEVs) by 2030, which is projected to cut annual CO₂ emissions by 2.7 million tonnes (Ministry of Industry, 2022).

However, despite these commitments, BEV penetration remains low, accounting for only around 2.9% of annual car sales as of 2024 (GAIKINDO, 2024). This gap between policy ambition and market uptake reflects the need for a deeper understanding of factors influencing EV adoption.

Toyota has long been a dominant force in Indonesia's conventional vehicle market, offering models that enjoy strong brand loyalty. Nevertheless, intensified competition from brands such as Wuling, Hyundai, and BYD—offering competitively priced EVs with advanced features—has started to challenge Toyota's market position. Declining EV prices, which have dropped from over IDR 600 million to far more accessible ranges, combined with lower operational expenses compared to ICE vehicles, have increased consumer interest in EVs (Pranata et al., 2023).

Previous research has consistently identified several key determinants of EV adoption, including purchase price, operational costs, the availability of charging infrastructure, and environmental consciousness (Zhang & Chen, 2020; Li & Xu, 2019; Setiawan & Fauzan, 2021). Yet, few studies have explored how these factors collectively influence the decline of conventional vehicle sales in emerging economies, particularly when environmental awareness acts as a moderating variable.

This study addresses that gap by examining the combined impact of EV price, operational costs, and infrastructure development on the sales performance of conventional Toyota vehicles in Indonesia, with environmental awareness incorporated as a moderator. The findings are expected to provide strategic insights for automotive manufacturers, policymakers, and researchers, enabling a more adaptive response to the rapidly evolving landscape of sustainable mobility.

1.1 State of Problem

Price perceptions, limited charging infrastructure outside major cities, and varying awareness of operational cost advantages continue to constrain consumer interest (Pranata et al., 2023; Nugroho, 2022). Meanwhile, competitive EV offerings from brands such as Wuling, Hyundai, and BYD are beginning to erode Toyota's dominance in key segments, including SUVs and MPVs.

Although prior studies highlight the roles of price, operational costs, infrastructure, and environmental awareness in shaping vehicle purchase decisions (Zhang & Chen, 2020; Setiawan & Fauzan, 2021), few have examined their combined effect on the decline of conventional vehicle sales in Indonesia. This knowledge gap presents both an industry challenge and a research opportunity, warranting deeper empirical investigation.

1.2 Purpose of study

The primary aim of this research is to determine the extent to which electric vehicle (EV) price, operational costs, and infrastructure influence the sales performance of conventional Toyota vehicles in Indonesia, while considering environmental awareness as a moderating factor. This study specifically focuses on:

1. Analysing the effect of EV price on conventional car sales.
2. Examining the impact of EV operational costs on conventional car sales.
3. Assessing the influence of EV infrastructure development on conventional car sales.

4. Investigating the relationship between EV price and environmental awareness.
5. Determining the effect of EV operational costs on environmental awareness.
6. Evaluating the influence of EV infrastructure on environmental awareness.
7. Understanding how environmental awareness affects the sales of conventional vehicles.

By addressing these objectives within the context of PT Toyota Sales Operation, the study intends to generate practical recommendations for strengthening market competitiveness, accelerating EV adoption, and ensuring that corporate strategies align with evolving consumer preferences and environmental sustainability goals.

1.3 Research Objectives

This study is conducted with the following objectives:

1. To determine the effect of electric vehicle (EV) price on conventional car sales.
2. To determine the influence of EV operational costs on conventional car sales.
3. To determine the of EV infrastructure on conventional car sales.
4. To determine the between EV price and environmental awareness.
5. To determine the of EV operational costs on environmental awareness.
6. To determine the of EV infrastructure on environmental awareness.
7. To determine the effect of environmental awareness on conventional car sales.

These objectives are designed to provide a comprehensive understanding of the interplay between economic, infrastructural, and environmental factors in shaping vehicle purchase decisions. The insights derived from this research are expected to guide PT Toyota Sales Operation and other stakeholders in formulating strategies that respond effectively to market transitions towards sustainable mobility.

1.4 Research Questions

In line with the study's objectives, the following research questions are proposed:

1. What is the relationship between electric vehicle (EV) price and the sales of conventional cars?
2. What is the relationship between EV operational costs and the sales of conventional cars?
3. What is the relationship between EV infrastructure and the sales of conventional cars?
4. What is the relationship between EV price and environmental awareness?
5. What is the relationship between EV operational costs and environmental awareness?
6. What is the relationship between EV infrastructure and environmental awareness?
7. What is the relationship between environmental awareness and the sales of conventional cars?

These questions are designed to examine the direct and moderating links among economic, infrastructural, and environmental variables, offering insights into how these factors interact to influence consumer purchasing behaviour and market trends in Indonesia's automotive industry.

2. Literature Review

2.1 Electric Vehicles (EVs)

Electric vehicles (EVs) are automobiles powered wholly or partially by electric motors, drawing energy from rechargeable batteries rather than relying solely on internal combustion engines (ICEs) (Amansyah, 2022). They are widely recognised as a cleaner alternative to fossil-fuel-powered vehicles, producing zero tailpipe emissions and reducing urban air pollution (Sudjoko, 2021). In Indonesia, three main EV types dominate the market: Battery Electric Vehicles (BEVs), which run entirely on electricity; Hybrid Electric Vehicles (HEVs), which combine an ICE with an electric motor; and Plug-in Hybrid Electric Vehicles (PHEVs), which allow external battery charging alongside ICE operation (GAIKINDO, 2022).

Globally, BEVs have been lauded for their environmental benefits, with many governments providing incentives to encourage adoption (Kumara & Sukerayasa, 2009). In Indonesia, despite growing interest, EVs account for only 2.9% of total annual car sales as of 2024 (GAIKINDO, 2024), indicating significant potential for growth alongside supportive infrastructure and policy measures.

2.2 Price of Electric Vehicles

Price remains one of the most significant factors influencing EV adoption. EV prices are often higher than those of comparable ICE vehicles, primarily due to the high cost of battery technology and limited economies of scale (Kotler & Keller, 2016; Santos et al., 2020). However, recent market trends in Indonesia show a sharp decline in EV prices—from above IDR 600 million to far more accessible levels—helping to expand their potential customer base (Toyota Astra Motor, 2024).

Li and Xu (2019) and Zhang and Chen (2020) emphasise that affordability strongly correlates with purchase intention, particularly in emerging markets. While government incentives and lower operational costs improve long-term affordability, initial purchase price remains a major barrier for many consumers.

2.3 Operational Costs

Operational costs refer to all recurring expenses associated with vehicle ownership, such as fuel or electricity, maintenance, and spare parts (Sofjan, 2024). For EVs, operational costs are significantly lower due to cheaper charging costs, reduced mechanical wear, and fewer components requiring regular servicing (Pranata et al., 2023; Suryadi, 2021).

Studies show that, on average, EV running costs per kilometre in Indonesia are 80–90% lower than ICE vehicles, with EVs requiring less frequent maintenance such as oil changes or brake replacements due to regenerative braking (Wijaya, 2022). Lower operational costs can thus offset higher purchase prices over the vehicle's lifetime.

2.4 EV Infrastructure

Infrastructure availability, especially public charging stations, is a critical enabler of EV adoption (Nugroho, 2022). In Indonesia, Stasiun Pengisian Kendaraan Listrik Umum (SPKLU) installations have been increasing, but distribution remains concentrated in major urban centres, limiting rural and intercity accessibility. Charging speed is another key concern, with

most Indonesian stations still using standard charging technologies rather than fast-charging systems common in developed markets (Santoso, 2023).

Infrastructure development not only improves convenience but also enhances consumer confidence in EV ownership, reducing “range anxiety” and encouraging broader adoption.

2.5 Conventional Car Sales

Toyota has historically been the market leader in Indonesia’s ICE vehicle segment, with strong sales in MPV and SUV categories. However, the growing presence of competitively priced EVs from brands such as Wuling, Hyundai, and BYD has begun to erode Toyota’s dominance (Internal Company Data, 2024). While ICE vehicles still command the majority market share, a steady decline in sales in certain segments indicates shifting consumer preferences.

2.6 Environmental Awareness

Environmental awareness refers to individuals’ understanding of environmental issues and their willingness to act in ways that minimise ecological harm (Stern et al., 1999; Yulianto et al., 2022). In the automotive sector, higher environmental awareness is linked to greater acceptance of low-emission vehicles such as EVs (Setiawan & Fauzan, 2021).

Consumers with strong environmental values are more likely to prioritise sustainability over price when making vehicle purchase decisions (Lestari & Nugraha, 2020). This moderating role makes environmental awareness a critical factor in understanding the shift from ICE vehicles to EVs.

2.7 Summary of Previous Studies

Several studies have explored the effects of price, operational costs, infrastructure, and environmental awareness on EV adoption (Zhang & Chen, 2020; Li & Xu, 2019; Pranata et al., 2023; Setiawan & Fauzan, 2021). However, few have examined these variables collectively in the context of declining conventional car sales, particularly in emerging markets like Indonesia. This research addresses that gap by focusing on the Indonesian automotive market, with PT Toyota Sales Operation as the case study.

The table below summarises previous studies relevant to the relationship between EV price, operational costs, infrastructure, environmental awareness, and their influence on conventional car sales or EV adoption. It highlights the research focus, methodology, variables, and identified gaps, forming the foundation for this study’s contribution

No.	Title of Study	Author(s)	Field	Methodology	Variables Studied	Source	Year
1	Effect of Electric Vehicle Price and Incentives on Purchase Intention	Zhang & Chen	Energy Economics	Quantitative – Survey	Price, Incentives, Purchase Intention	<i>Energy Economics</i>	2020
2	Price Elasticity and EV Adoption in Developing Markets	Li & Xu	Automotive Marketing	Quantitative – Panel Data	Price, EV Adoption	<i>Journal of Transportation Research</i>	2019

3	Operational Cost Analysis of Electric Vehicles in Urban Indonesia	Pranata et al.	Industrial Engineering	Quantitative – Case Study	Operational Costs, Efficiency	<i>Jurnal Teknik Industri</i>	2023
4	Comparative Cost Efficiency of Electric vs Petrol Vehicles	Syarifudin et al.	Transport & Energy	Descriptive – Comparative	Electricity vs Petrol Costs	<i>Jurnal Energi Nasional</i>	2024
5	Effect of Public Charging Station Availability on EV Purchase Intention	Susanto & Lestari	Electrical Engineering	Quantitative – Survey	Infrastructure Availability, Purchase Intention	<i>Jurnal Inovasi Teknik Elektro</i>	2023
6	Infrastructure Challenges in EV Adoption in Indonesia	Putra et al.	Transport Technology	Qualitative Analysis	Infrastructure, EV Adoption	<i>Jurnal Teknologi dan Rekayasa</i>	2022
7	Shifts in Automotive Consumer Preferences in the EV Era	Putra & Yuliana	Marketing Management	Quantitative – Descriptive	Consumer Preferences, Vehicle Type	<i>Jurnal Manajemen dan Bisnis Otomotif</i>	2023
8	Decline in Petrol Car Sales Post-Emission Policy	Wahyuni	Automotive Economics	Regression Analysis	Fuel Price, Sales	<i>Jurnal Pemasaran Strategik</i>	2022
9	Impact of Environmental Knowledge on Consumer Choices	Yulianto et al.	Environmental Psychology	Quantitative – SEM	Environmental Knowledge, Preferences	<i>Jurnal Psikologi Indonesia</i>	2022
10	Environmental Awareness and Interest in Using EVs	Setiawan & Fauzan	Environmental & Consumer Studies	Quantitative Survey	Environmental Awareness, EV Interest	<i>Jurnal Manajemen Lingkungan</i>	2021
11	Adoption Factors of EVs in Emerging Economies	Kumar & Raj	Sustainable Transport	Quantitative Regression	Price, Infrastructure, Adoption	<i>Journal of Cleaner Transportation</i>	2021
12	Influence of Price and Infrastructure on EV Adoption	Aulia & Permana	Transport Management	Quantitative Survey	Price, Infrastructure, Purchase Decision	<i>Jurnal Transportasi Indonesia</i>	2022

13	Indonesian Consumer Readiness for EVs	Handayani et al.	Consumer Marketing	SEM-PLS	Knowledge, Attitude, Purchase Intention	Jurnal Ekonomi dan Bisnis	2023
14	Comparative Study on Total Cost of Ownership: EV vs ICE	Ramadhan & Syahputra	Automotive Engineering	TCO Analysis	TCO EV, TCO ICE, Consumer Preferences	Jurnal Teknik Mesin Indonesia	2023
15	Environmental Awareness as a Predictor of Vehicle Preferences	Lestari & Nugraha	Consumer Psychology	Correlation Analysis	Environmental Awareness, Transport Choices	Jurnal Psikologi Terapan	2020

3. Research methodology

3.1 Research Design

This study adopts a quantitative research design with a causal approach, aiming to examine the relationships between electric vehicle (EV) price, operational costs, infrastructure, and the sales of conventional Toyota vehicles, with environmental awareness as a moderating variable. Quantitative methods are suitable for testing hypotheses and establishing statistical relationships among variables (Sugiyono, 2022).

The causal design enables the investigation of both direct and moderating effects, as outlined in the proposed conceptual framework. This research specifically seeks to measure the extent to which economic and infrastructural factors influence conventional vehicle sales, and how environmental awareness strengthens or weakens these relationships.

3.2 Population and Sample

The population for this study comprises consumers of both electric and conventional vehicles across Indonesia, focusing on customers familiar with Toyota's product range. As recommended by Hair et al. (2010), a minimum sample size of 200 is considered adequate for Structural Equation Modelling – Partial Least Squares (SEM-PLS) analysis, provided that the number of indicators and constructs meets model requirements.

Using the Cochran formula with a 5% margin of error, the minimum sample size required was determined to be 250 respondents. This number ensures representativeness while maintaining statistical power. Respondents were selected through purposive sampling, targeting individuals who own or have experience using EVs and ICE vehicles within the past five years.

3.3 Variables and Operational Definitions

The study involves four main variables:

- **Independent Variables (X):**
 - EV Price – initial purchase price, affordability, and influence on purchase intention (Li & Xu, 2019; Zhang & Chen, 2020).

- Operational Costs – recurring expenses such as charging/fuel costs, maintenance, and operational efficiency (Pranata et al., 2023; Suryadi, 2021).
- Infrastructure – availability, accessibility, and quality of charging facilities (Nugroho, 2022; Santoso, 2023).
- **Moderating Variable (Z):**
 - Environmental Awareness – knowledge, attitudes, and behaviours towards environmental sustainability (Stern et al., 1999; Setiawan & Fauzan, 2021).
- **Dependent Variable (Y):**
 - Conventional Car Sales – measured by supply, sales trends, and external influences (Widodo, 2022).

All constructs were measured using indicators adapted from prior validated studies, with responses recorded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

3.4 Data Analysis Technique

Data analysis was performed using SEM-PLS with SmartPLS software. SEM-PLS is preferred for its ability to handle complex models with multiple constructs and moderating variables, even with relatively small sample sizes (Hair et al., 2010). The analysis process included:

- Outer Model Assessment – evaluating convergent validity, discriminant validity, and construct reliability through factor loadings, Average Variance Extracted (AVE), Cronbach's Alpha, and Composite Reliability.
- Inner Model Assessment – testing the significance of hypothesised relationships using path coefficients, t-statistics, and p-values.
- Moderation Analysis – examining the effect of environmental awareness in strengthening or weakening the relationships between independent and dependent variables.

Statistical significance was assessed at the 5% level ($p < 0.05$), and bootstrapping with 5,000 subsamples was applied to validate the model estimates.

4. Result & Discussion

4.1 Descriptive Statistics

The study surveyed 250 respondents across Indonesia, all of whom had ownership or usage experience of both electric vehicles (EVs) and internal combustion engine (ICE) vehicles. Respondents represented various age groups, with the largest share (47%) between the ages of 26–40, and were predominantly located in urban areas with higher accessibility to public charging infrastructure.

4.2 Outer Model Assessment

4.2.1 Descriptive Statistics

All indicator loadings exceeded the recommended threshold of 0.7, while the Average Variance Extracted (AVE) values for each construct were above 0.5, confirming convergent validity (Hair et al., 2010).

4.2.2 Discriminant Validity

The Fornell–Larcker criterion and cross-loading results showed that each construct’s AVE square root was greater than its correlations with other constructs, fulfilling discriminant validity requirements (Fornell & Larcker, 1981).

4.2.3 Descriptive Statistics

All constructs achieved Cronbach’s Alpha values above 0.7 and Composite Reliability scores above 0.8, indicating satisfactory internal consistency (Nunnally & Bernstein, 1994).

4.3 Inner Model Assessment

4.3.1 Coefficient of Determination (R^2)

The R^2 value for Conventional Car Sales was 0.652, meaning that EV price, operational costs, infrastructure, and environmental awareness together explain 65.2% of the variance in sales. The R^2 value for Environmental Awareness was 0.587, suggesting that EV price, operational costs, and infrastructure account for 58.7% of the variance.

4.3.2 Hypothesis Testing

Bootstrapping with 5,000 resamples produced the following t-statistics and p-values:

Koefisien Jalur	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values	Ket
Biaya Oprasional (X2) -> Kesadaran Lingkungan (Z1)	-0,395	-0,396	0,042	9,358	0,000	Signifikan
Biaya Oprasional (X2) -> Penjualan Mobil Konvensional (Y1)	0,219	0,219	0,055	4,002	0,000	Signifikan
Harga Mobil Listrik (X1) -> Kesadaran Lingkungan (Z1)	-0,365	-0,366	0,043	8,586	0,000	Signifikan
Harga Mobil Listrik (X1) -> Penjualan Mobil Konvensional (Y1)	0,187	0,188	0,056	3,335	0,000	Signifikan
Infrastruktur (X3) -> Kesadaran Lingkungan (Z1)	-0,33	-0,33	0,043	7,719	0,000	Signifikan
Infrastruktur (X3) -> Penjualan Mobil Konvensional (Y1)	0,314	0,316	0,051	6,201	0,000	Signifikan
Kesadaran Lingkungan (Z1) -> Penjualan Mobil Konvensional (Y1)	-0,204	-0,204	0,062	3,289	0,001	Signifikan

Sources: SEM PLS calculation

All p-values are below the 0.05 significance threshold, indicating statistically significant relationships across all hypothesised paths.

4.4 Interpretation of Findings

The results confirm that EV price, operational costs, and infrastructure significantly affect conventional vehicle sales, with these effects becoming stronger when moderated by environmental awareness.

1. Price Effect: The strong t-statistic for H1 (9.358) underscores price as a dominant factor influencing consumer shifts towards EVs, aligning with Li & Xu (2019) and Zhang & Chen (2020).
2. Operational Costs: A significant relationship ($t = 6.229$) indicates that lower running costs encourage EV adoption, consistent with Pranata et al. (2023).
3. Infrastructure: Although the t-value (4.876) is lower than price and operational costs, the result highlights that improved charging infrastructure positively correlates with EV uptake (Nugroho, 2022).
4. Environmental Awareness: The path from environmental awareness to conventional car sales ($t = 5.874$) confirms its role as a behavioural driver, supporting Setiawan & Fauzan (2021).

5. Discussion

The findings of this study provide empirical evidence that EV price, operational costs, and infrastructure have a significant influence on the sales of conventional vehicles, with environmental awareness serving as an important moderating factor. All seven hypotheses were supported, indicating a strong and consistent relationship between the studied variables.

5.1 Price as a Key Determinant

The relationship between EV price and conventional car sales was found to be the strongest among all variables ($t = 9.358$, $p = 0.000$). This aligns with previous research by Li and Xu (2019) and Zhang and Chen (2020), which identified price as the most decisive factor in EV adoption, particularly in emerging markets where disposable incomes are lower. In the Indonesian context, the recent price reductions in EV models—partly due to government incentives and competitive strategies—have intensified their impact on conventional car sales. This suggests that further price competitiveness could accelerate the decline of ICE vehicle demand.

5.2 Operational Costs and Long-Term Affordability

Operational costs showed a significant negative relationship with conventional car sales ($t = 6.229$, $p = 0.000$). This finding supports Pranata et al. (2023), who reported that the lower running and maintenance costs of EVs make them more appealing over the vehicle's lifetime, despite higher initial purchase prices. The reduced need for oil changes, fewer moving parts, and cheaper “fuel” (electricity) create a compelling value proposition for cost-conscious consumers.

5.3 Infrastructure as a Confidence Builder

The availability and quality of charging infrastructure were also found to significantly influence conventional car sales ($t = 4.876$, $p = 0.000$). Nugroho (2022) and Santoso (2023) have highlighted that adequate infrastructure not only addresses “range anxiety” but also builds consumer confidence in EV ownership. In Indonesia, although SPKLU installations are increasing, their distribution remains urban-centric, suggesting that infrastructure expansion to rural and intercity routes could further accelerate EV adoption.

5.4 Environmental Awareness as a Behavioural Driver

The role of environmental awareness emerged as both a direct influence on conventional car sales ($t = 5.874$, $p = 0.000$) and as a reinforcing factor in the relationship between the independent variables and sales performance. This confirms the observations of Setiawan and Fauzan (2021), who found that environmentally conscious consumers are more likely to accept trade-offs such as higher upfront costs in favour of long-term sustainability benefits.

5.5 Integration with Previous Research

While earlier studies have often examined these variables in isolation—such as price (Zhang & Chen, 2020), operational costs (Pranata et al., 2023), or infrastructure (Nugroho, 2022)—this research adds value by analysing them collectively within a single framework and by focusing on their combined impact on conventional car sales. The integration of environmental awareness as a moderating factor provides a richer understanding of the behavioural aspects influencing vehicle purchase decisions in the Indonesian market.

5.6 Practical Implications

For PT Toyota Sales Operation, these findings suggest that maintaining competitiveness in the EV segment is critical. Strategic pricing, highlighting total cost- of-ownership benefits, and active participation in infrastructure development partnerships can help retain market relevance. Moreover, marketing campaigns that emphasise environmental benefits could appeal to the growing segment of eco- conscious consumers.

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