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From Incentives to Adoption: A Decadal Review of India's EV Subsidy Effectiveness

An Econometric Assessment of Differential Policy Impact Across Vehicle Segments

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The authors assume full responsibility for any errors or omissions in this report.

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सत्यमेव जयते

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Foreword

As India advances its development journey, a dual challenge of sustaining economic growth while addressing urgent environmental concerns is right before us. Our Hon'ble Prime Minister has laid down the contours of new mobility with attributes as Common, Connected, Convenient, Congestion-free, Charged, Clean and Cutting-edge. Govt. of India is committed to de-carbonize transport sector.

The future will be zero tail pipe emission vehicles. The electric vehicles are fast becoming the norm rather than the exception across all segments – from the ubiquitous two-wheelers to commercial vehicles that power the economy. We have very aspirational target for ourselves. This requires a complete support to all elements of EV Ecosystem.

Translating this vision into reality will require substantial public investment. Through programmes like FAME-I, FAME-II, and now PM E-DRIVE, along with Production-Linked Incentive Schemes, the Government of India has been committed to catalysing this EV transition. The future support mechanisms must be adjusted in line with the ecosystem requirements.

I am pleased that this pioneering study 'From Incentives to Adoption: A Decadal Review of India's EV Subsidy Effectiveness' directly addresses this knowledge gap. I acknowledge the effort put forward by the Institute for Energy Economics and Financial Analysis (IEEFA) in undertaking such a study. By examining a decade of data across India's diverse vehicle segments, researchers have provided what has long been missing – a data-driven evaluation of the EV purchase incentives and their impact on adoption patterns. The econometric approaches employed bring scientific precision to what was previously assessed primarily through anecdotal evidence. I also acknowledge the contributions made by Shakti Sustainable Energy Foundation, as a knowledge partner, to the study.

The findings offer valuable guidance for the purchase incentive policy framework. The varied effectiveness of interventions across vehicle categories confirms what many of us have observed but couldn't quantify: one-size-fits-all approaches are insufficient for India's complex mobility ecosystem. Understanding where FAME schemes have successfully stimulated market growth and where state interventions have complemented central efforts will enable more targeted policy design.

While this study illuminates purchase subsidies, there is also a need to understand the effectiveness of investments in charging infrastructure, manufacturing capacity, financing mechanisms, and regulatory frameworks. Only through comprehensive evaluation can a cohesive strategy be designed that accelerates India's transition to electric mobility while maximizing return on public investment.

My congratulations to the team of authors who have completed this Report and I am sure their collective effort will help to build a cleaner, more sustainable transportation system for India.

(Sudhendu J. Sinha)

28th May, 2025
New Delhi

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Figures and Tables

Glossary

ACC – Advanced Chemistry Cell
AR – Adoption Rate
ATE – Average Treatment Effect
BEE – Bureau of Energy Efficiency
CEA – Central Electricity Authority
CESL – Convergence Energy Services Limited
CNG – Compressed Natural Gas
CO_2e – Carbon dioxide Equivalent
CSI – Central Subsidy Intensity
DiD – Difference-in-Differences
E2Ws – Electric Two-Wheelers
E3WC – Electric Three-Wheeler Cargo
E3WP – Electric Three-Wheeler Passenger
E4WC – Electric Four-Wheeler Commercial
e-buses – Electric Buses
EMPS 2024 – Electric Mobility Promotion Scheme 2024
EV – Electric Vehicles
FAME - Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles
GCC – Gross Cost Contract
GDP – Gross Domestic Product
GST – Goods and Services Tax
ICE – Internal Combustion Engines
kWh – Kilowatt Hour
MHI – Ministry of Heavy Industry
MoFHW – Ministry of Health and Family Welfare
NSSO – National Sample Survey Office
OEMs – Original Equipment Manufacturers
PLFS – Periodic Labour Force Surveys
PLI – Production Linked Incentive
PM E-DRIVE – Prime Minister Electric Drive Revolution in Innovative Vehicle Enhancement
PSM – Propensity Score Matching
R&D – Research and Development
RBI – Reserve Bank of India
SCM – Synthetic Control Method
SI – Subsidy Intensity
STUs – State Transport Undertakings
TCO – Total Cost of Ownership
UTs – Union Territories

Key Findings

While central subsidies under FAME-I and FAME-II, and state incentives have successfully given a boost to absolute EV sales, their effectiveness differs across segments.

Market multipliers reached up to 9-21x across segments, indicating each subsidy rupee potentially catalysed much larger market creation beyond direct policy impacts.

For commercial segments like E3W Cargo and E4W Commercial, while purchase subsidies remain important, economic fundamentals like favourable operating costs serve as complementary drivers of adoption.

Segment-specific fiscal interventions are essential due to differing levels of market maturity and barriers across EV categories.

Executive Summary

India is committed to reducing the emissions intensity of its GDP by 45% by 2030 from 2005 levels, and achieving net zero emissions by 2070, as part of its Nationally Determined Contributions under the Paris Agreement. Achieving these goals requires a fundamental shift across sectors, with the transportation sector—accounting for approximately 14% of India's energy sector carbon dioxide emissions—being critical for decarbonisation. At the same time, India is positioning itself as a global hub for electric vehicle (EV) manufacturing, aiming to harness domestic scale to drive industrial growth, reduce import dependence and create green jobs.

To drive this transformation, India has introduced a wide range of policies, such as purchase subsidies, production-linked incentives and regulatory mandates, to promote the uptake of EVs. Electrifying mobility can curb emissions, reduce fossil fuel dependence and improve air quality. Reflecting this ambition, the Indian government aims to increase the share of EV sales to 30% in private cars, 70% in commercial vehicles, 40% in buses and 80% in two- and three-wheelers by 2030.

However, despite ambitious goals, the EV industry continues to face challenges, such as high upfront costs, expensive financing, a nascent domestic battery supply chain, limited charging infrastructure and the absence of national EV sales targets. The central and state governments have implemented various fiscal and non-fiscal support measures, earmarking substantial funds to catalyse market growth. Yet, a crucial question remains largely unanswered: how effective are these government interventions in driving EV adoption across vehicle segments?

In this study, we provide the first comprehensive empirical assessment of India's EV fiscal support policies, examining their effectiveness across major vehicle categories. Our analysis spans a decade (2014-23) and offers insights into how fiscal incentives and other government policies influence EV market uptake. We employ advanced econometric techniques, including difference-in-differences and synthetic control methods, to establish causal relationships between policy interventions and market outcomes. We summarise our key findings below:

Electric two-wheelers (E2Ws): The introduction of higher subsidies under Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles[1] in India-II (FAME-II) significantly increased E2W sales, with a 12.7% jump in sales for every one-standard-deviation increase in subsidy intensity.[2] The analysis revealed a potential maximum market multiplier effect of up to 9×, where approximately 1.63 lakh E2Ws directly attributable to FAME-II subsidies contributed to total sales, reaching 14.4 lakh units during the policy period. State incentives further amplified this growth, with our analysis showing states implementing supportive policies achieved 54.5% higher E2W sales compared to

[1] As introduced; hybrids vehicles, particularly in the car segment, were excluded from FAME post-2017.
[2] One standard-deviation is a statistical way to describe a typical amount of variation around the average measure of a variable. In this case, one standard-deviation increase is equivalent to raising the per kWh subsidy intensity from its average level in the sample by 5.39 percentage points.

those with only central policies. However, the adoption rate—the share of E2W sales in total 2W sales—remained a modest 4% at the end of 2023. While central and state policies have been effective in driving absolute sales growth, they have had limited success in increasing market share due to barriers, such as entrenched consumer preference for internal combustion engines (ICEs), inadequate charging infrastructure, and concerns over residual value.

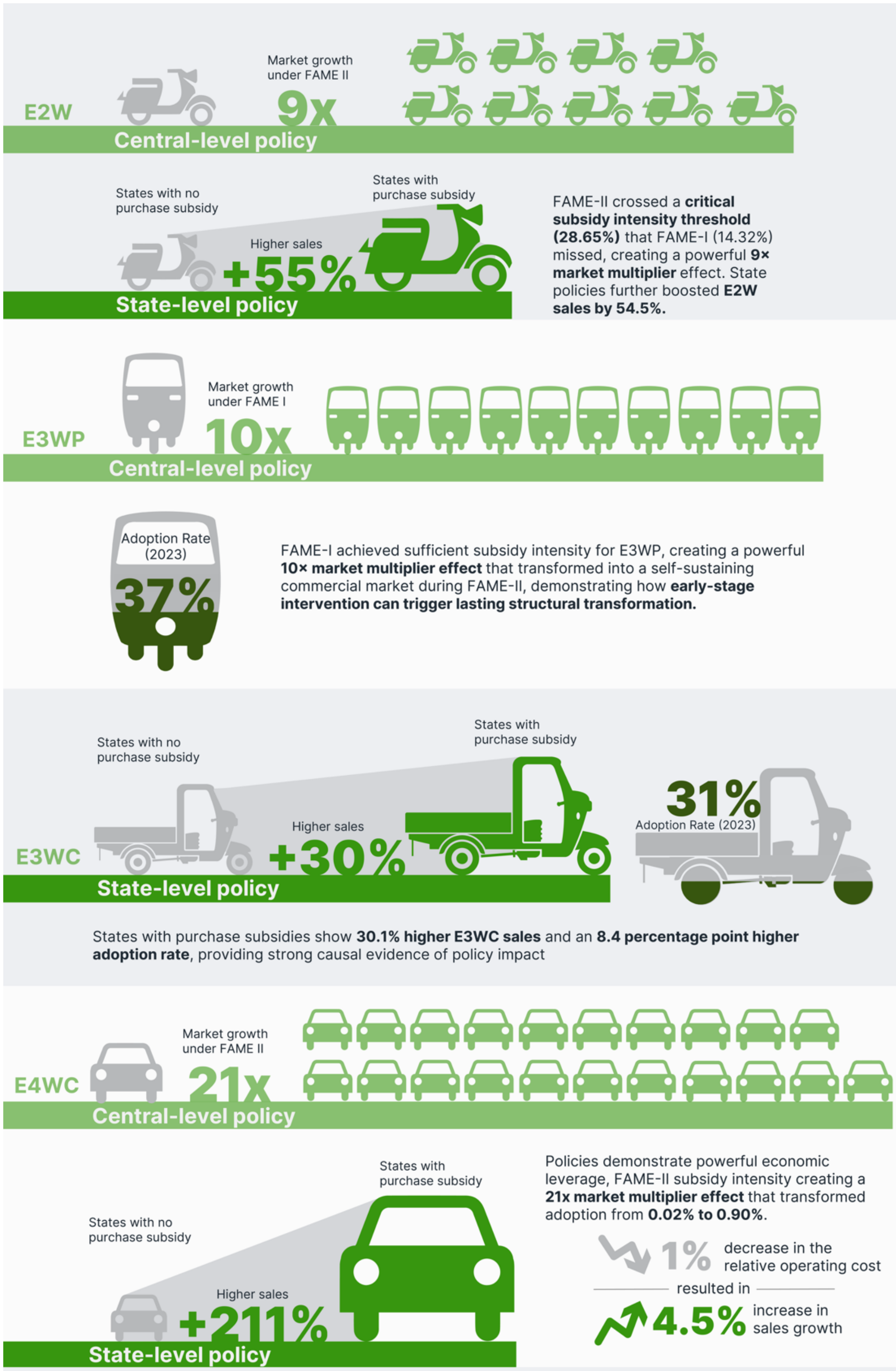
Electric three-wheeler passenger (E3WP): FAME-I played a pivotal role in catalysing the E3WP market, with a significant multiplier effect on sales. Our statistical analysis indicates that approximately 27,000 additional E3WPs can be directly attributed to FAME-I subsidies, while actual sales reached 2.67 lakh units by March 2019, suggesting a multiplier ratio of up to 10×. For every E3WP statistically linked to subsidy intensity, up to 10 units materialised in actual sales. However, the transition to FAME-II had a limited direct impact on sales, indicating that the segment had matured beyond reliance on subsidies. Our study suggests that market-led expansion is now the primary driver of E3WP growth, supported by factors like favourable total cost of ownership (TCO) and local regulatory measures.

Electric three-wheeler cargo (E3WC): Despite weak statistical evidence for direct (central) subsidy impact, the E3WC segment has grown substantially, driven by operational cost advantages. Our regression analysis reveals that for every 1% decrease in operating costs relative to ICE vehicles, E3WC sales increased by 0.563% while adoption rates rose by 0.167%. This operational efficiency has helped transform the segment from virtually non-existent (0.03% market share) in 2015 to capturing nearly one-third of the market (31.04%) by 2023. States implementing supporting policies recorded 30.1% higher sales and 8.4 percentage points higher adoption rates than those without such policies. Our panel regression further demonstrates that a one standard deviation increase in state subsidy intensity leads to a 46.16% increase in E3WC sales and a 9.26 percentage point increase in adoption rate. This underscores the importance of state policies in complementing central initiatives, particularly in bridging cost gaps for vehicle categories with higher prices due to bigger batteries.

Electric four-wheeler (commercial) (E4WC): FAME-II and Production Linked Incentives contributed significantly to the growth of the E4WC segment, with a substantial increase in sales and a modest improvement in adoption rates. States implementing supporting policies also witnessed 211% higher sales growth compared with states that did not provide purchase incentives. However, maintaining a minimum subsidy threshold to offset high upfront costs and focusing on supply-side interventions are essential to ward off competition from ICE vehicles, especially the compressed natural gas (CNG) vehicles in this segment.

Electric four-wheeler (private) (E4WP): Electric car direct subsidies were mostly directed toward E4WC during FAME I and II given the concerns surrounding the environmental footprint of private cars. While the E4WP segment has experienced sales growth with the launch of new models and consumer demand, the adoption rate remains below 2%. Policy support is still essential in terms of both fiscal and non-fiscal measures to achieve the vision of 30% electric cars in private cars by 2030.

ES Figure 1: Segment-specific EV Policy Impact Across India (2014-23)



This figure summarizes how central and state fiscal policies impact four key electric vehicle segments, illustrating market multiplier effects. It shows varying policy effectiveness across segments, with some achieving market sustainability through early subsidies while others remain highly responsive to ongoing incentives, reflecting their different market maturity levels and adoption barriers.

Electric buses (e-buses): Despite substantial subsidies under both FAME-I (up to Rs4.1 million per bus) and FAME-II (Rs20,000/kWh, capped at 40% of ex-showroom price), e-bus adoption remained modest with 4,766 units subsidised against a target of 7,262. Our analysis found no statistically significant positive effect of any central or state policy on e-bus sales or adoption rates. This underperformance stemmed from several structural limitations: procurement was restricted to state transport undertakings (STUs), which represent less than 7% of India's bus fleet; tender-based aggregated demand mechanisms failed to stimulate organic market growth; e-buses remained 2-3 times more expensive than diesel alternatives despite subsidies; and smaller private operators, who make up the majority of the sector, struggled to access suitable financing.

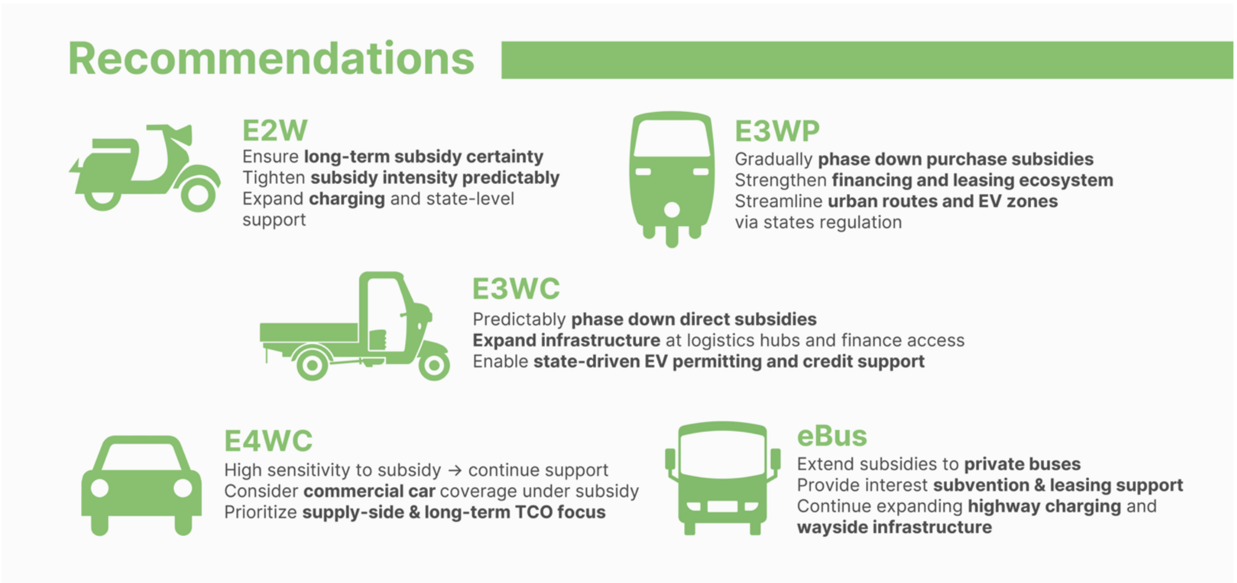
These findings have significant implications for policymakers transitioning from FAME schemes to newer initiatives, such as PM E-DRIVE.

First, the next phase of policy support must extend beyond purchase subsidies to encompass robust charging infrastructure and accessible low-cost financing. Second, the differing maturity levels of each EV segment call for more nuanced strategies, blending demand- and supply-side options to tackle specific cost or regulatory bottlenecks. Third, strong coordination between central and state policies can amplify results, especially for segments still grappling with affordability.

Finally, as central subsidies taper, states will play a growing role in driving adoption through fiscal and non-fiscal measures. However, given their limited revenue and reliance on central transfers, their capacity to sustain fiscal support is constrained. To ensure balanced and sustained progress, the central government must continue to anchor fiscal support, given its stronger resource base, while states can play a catalytic role through targeted fiscal and non-fiscal measures and by facilitating access to affordable finance through support to Non-Banking Financial Companies (NBFCs) and localised credit instruments.

While India has made significant strides in promoting EV adoption through its policies, achieving deeper market penetration will require a combination of sustained financial incentives, infrastructure development, accessible low-cost finance and regulatory innovation. This study provides valuable insights to inform future policy decisions that can accelerate the transition to electric mobility and decarbonise the transportation sector.

ES Figure 2: Key Policy Recommendations



This figure summarises the key policy recommendations for different electric vehicle segments in India including subsidy approaches, infrastructure development priorities, and segment-specific interventions to accelerate adoption across E2W, E3WP, E3WC, E4WC, and e-Bus categories.

Introduction: India's EV Ambition

India aims to reduce the emissions intensity of its gross domestic product by 45% by 2030 compared to 2005 levels and has pledged to achieve net-zero by 2070 as part of its Nationally Determined Contributions under the Paris Agreement. Achieving these targets requires a fundamental shift in how the country produces and consumes energy, with the transportation sector playing a critical role in this transition. The transportation sector contributes approximately 14% of India's energy sector-related carbon dioxide emissions with 90% coming from road transportation.[3] While subsectors such as shipping, aviation and railways contribute to the sector's overall emissions footprint, it is road transport—comprising private vehicles, commercial fleets and public transit—that remains the most pressing challenge and, conversely, the greatest opportunity for decarbonisation.

Recognising this, India has laid out a plan for increasing the share of electric vehicle (EV) sales to 30% in private cars, 70% in commercial vehicles, 40% in buses and 80% in two- and three-wheelers by 2030.[4] In absolute numbers, this could translate to 80 million EVs on Indian roads by 2030, indicating a transitional shift. The electrification of these segments is expected to play a crucial role in reducing fossil fuel dependency, improving urban air quality, and aligning India's transport sector with its broader climate and energy security goals.

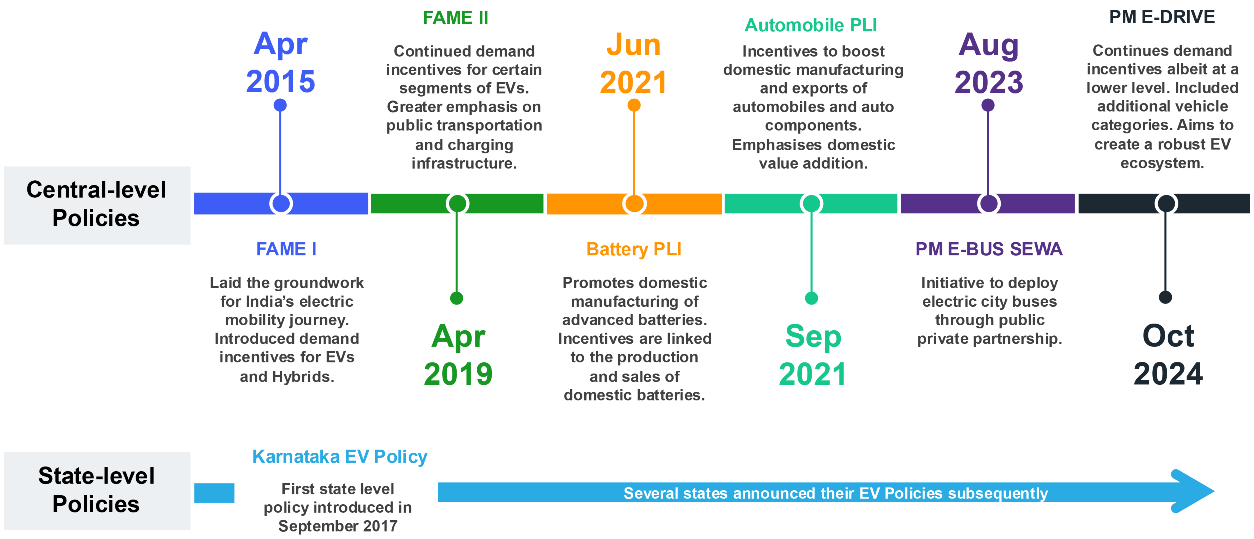
Evolving EV Policy Landscape

The union and state governments have drafted various supporting policies to encourage the deployment of EVs **(Figure 1)**. The Indian government's emphasis on subsidies and Production-Linked Incentives (PLIs) to drive EV adoption addresses fundamental market failures inherent in transitioning from fossil fuels.

However, the automotive industry continues to face challenges when it comes to EV manufacturing and increasing EV adoption rates. One major hurdle is the lack of a national target (mandate) for EV sales, which leads to demand uncertainty for manufacturers and investors, making long-term planning and capacity expansion difficult.[5] Without clear sales targets, time-bound transitions may be difficult. Another challenge is the lack of a well-established domestic supply chain for battery manufacturing. On the consumer side, the adoption of EVs is limited due to their high upfront costs, higher cost of finance and shorter loan tenors, and limited availability of charging infrastructure.

[3] ICCT. Decarbonizing India's Road Transport: A Meta-Analysis of Road Transport Emissions Models. May 2022.
[4] The Economic Times. Govt. intends to have EV sales penetration of 30% for private cars by 2030. October 2021.
[5] Maharashtra and Delhi have EV sales mandates.

Figure 1: Timeline of Key EV Policies in India



Source: Government documents

Conventional vehicles externalise environmental and health costs through pollution, while EV buyers bear higher upfront prices for public benefits like cleaner air and reduced oil imports. In the absence of an effective pricing of climate externality, subsidies correct this imbalance by aligning private incentives with public goods. Additionally, EVs face an interdependence problem—charging infrastructure requires widespread adoption to be viable, yet consumers hesitate to purchase EVs without reliable infrastructure. Targeted subsidies break this stalemate by stimulating initial demand, which incentivises private investment in ancillary networks and encourages manufacturers to scale up production. Meanwhile, PLIs address supply-side barriers by fostering domestic battery and auto component manufacturing, reducing dependency on imports and enabling long-term cost reduction through economies of scale. These policies include a mix of fiscal and non-fiscal support measures that incentivise domestic manufacturing and promote the adoption of EVs through purchase subsidies, tax benefits and infrastructure development.

“Conventional vehicles externalise environmental and health costs through pollution, while EV buyers bear higher upfront prices for public benefits like cleaner air and reduced oil imports. In the absence of an effective pricing of climate externality, subsidies correct this imbalance by aligning private incentives with public goods.

Other fiscal incentives such as accelerated depreciation, GST input credits, interest-rate subventions, and similar capital-expenditure benefits reduce the total cost of ownership (TCO) via tax or financing channels that accrue gradually rather than through an immediate showroom discount. Since the realisation of these savings depends on individual buyers' tax liabilities, financing arrangements, and asset-holding periods, isolating their marginal impact on EV adoption using registration data becomes challenging. Such indirect interventions, though valuable, operate via financial intermediaries or tax structures, further diffusing their effects and complicating empirical assessment. In contrast, upfront purchase subsidies offer an immediate and transparent price reduction, facilitating a clearer assessment of their impact on consumer behaviour, while PLIs, tied explicitly to production milestones, provide more measurable outcomes for domestic manufacturing performance.

In this study, we focus on purchase subsidies and PLI schemes as they represent the most significant fiscal policy interventions in India's EV sector. These policies account for the largest share of government expenditure and provide quantifiable metrics with robust available data. Our primary objective is to test the impact of these policies—specifically, how effectively they accelerate the adoption of EVs. While we recognise the role of other financial incentives in shaping the EV market, their effects are often embedded within broader economic trends, making it difficult to establish clear causal relationships.

To implement these policies/programmes, the central government has earmarked substantial funds spread over several years **(Table 1)**. While some initiatives have fully utilised their allocated budgets, others have had to restructure their spending to align with evolving market demand. Meanwhile, key initiatives such as PLI schemes, PM E-DRIVE and e-BUS SEWA remain active, continuing to drive EV adoption and ecosystem development.

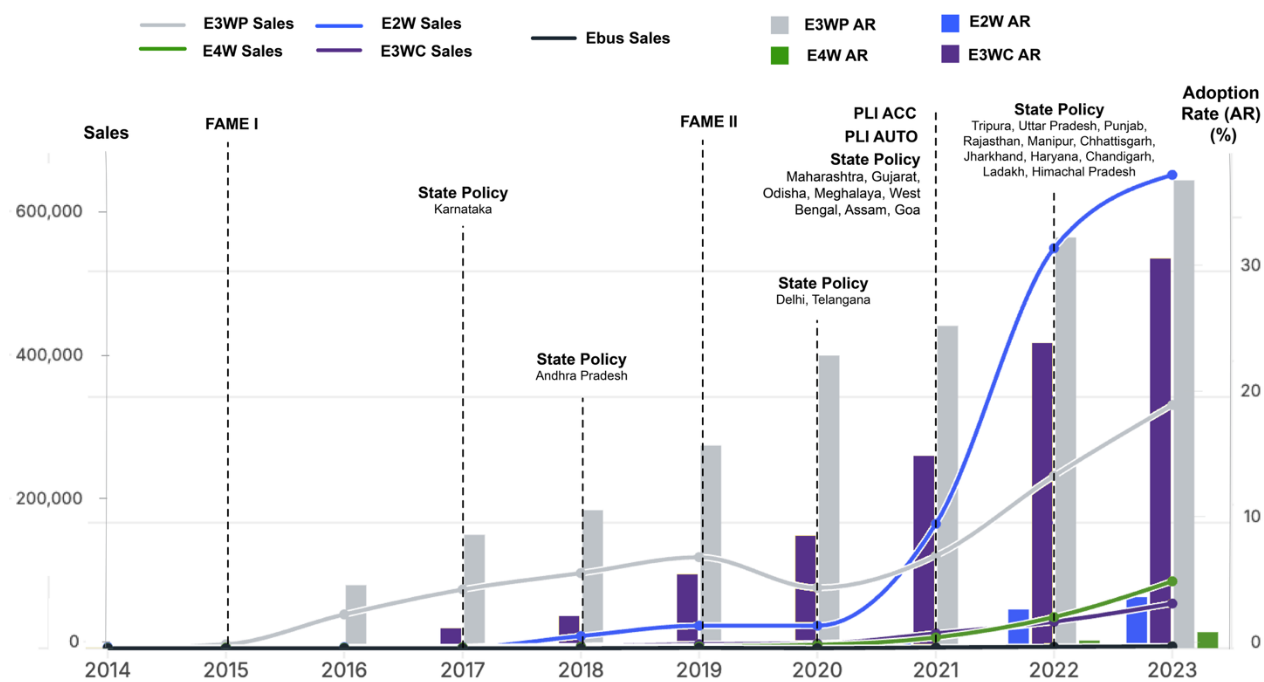
Table 1: Budget outlay for incentives under various central government EV policies

Policy	Budget Outlay	
	Rs million	**US$ million**
FAME I	8,950	108
FAME II	115,000	1,386
EMPS 2024	5,000	60
PM E-DRIVE	109,000	1,313
PM e-BUS SEWA	34,350	414
Automobile and Auto Components PLI	259,380	3,125
Battery PLI	181,000	2,181
Total	712,680	8,587

Source: Ministry of Heavy Industry, GoI and Press Information Bureau (PIB) (Exchange rate: Rs83 = US$1)

Figure 2 presents a consolidated view of how EV sales and adoption rates have evolved across segments from 2014 to 2023, in alignment with key national policy interventions. The chart serves as a visual foundation for the empirical work that follows, highlighting the distinct trajectories of each EV category over time.

Figure 2: EV sales and Adoption Rates across segments from 2014 to 2023



Source: VAHAN Dashboard, GoI; IEEFA Analysis

Research Focus: Measuring the Impact of India's EV Purchase Subsidies

This study aims to offer data-driven insights into how different fiscal levers—chiefly, demand side purchase subsidies at both the central and state levels, and supply side PLI programme—have shaped EV adoption across key vehicle categories. Although PLI is geared towards bolstering domestic manufacturing, we restrict its analysis to sales and adoption outcomes due to the limited availability of supply-side indicators (e.g., production capacity or local content).

One of our focus areas is the impact of subsidy intensity (SI)—the share of an EV's upfront price offset by a given purchase subsidy—and how variations in this intensity under FAME-I and FAME-II correlate with monthly EV sales and market share in two-wheelers, three-wheelers, four-wheelers (commercial) and buses. SI quantifies the relative magnitude of financial support provided by a government or institution, enabling the analysis of how different subsidy levels influence market outcomes. Using monthly panel data, we can determine whether increasing SI directly boosts EV sales and adoption rates.[6]

We also evaluate the additional impact of state purchase incentives, layered on top of central subsidies. Many states provide fiscal support, but the question remains: do state subsidies drive significantly higher EV uptake, or are they merely following regions already on a growth trajectory?

Additionally, our study attempts to bridge a crucial analytical gap by examining how manufacturing incentives like PLI ultimately influence consumer purchases. While PLI directly targets battery and auto component manufacturers, we investigate whether these upstream benefits effectively translate into higher EV sales through reduced vehicle prices which are primarily the demand side measures. To overcome the absence of direct manufacturing data, we developed a "PLI subsidy intensity" metric that allocates the total PLI budget proportionally across EV segments based on their respective sales volumes. This approach provides valuable indirect evidence of how manufacturing incentives flow through the value chain to impact consumer markets.[7]

By mapping how central and state support converge in the marketplace, we offer a nuanced view of which incentives are most effective, under what circumstances, and for which vehicle segments.

While charging infrastructure is a critical component of the EV ecosystem, this study does not evaluate the relationship between fiscal incentives and charging infrastructure deployment, nor does it assess how infrastructure availability impacts EV adoption. This limitation stems from insufficient historical data on charging stations, with records spanning only two years—too brief a period for meaningful empirical analysis. These important relationships remain opportunities for future research as longer-term datasets become available.

Motivation

India's EV support policies have evolved continuously since FAME-I, driven by increased fiscal and non-fiscal incentives, infrastructure development and refined policies. Our core motivation is to understand and quantify the deployment efficiency of the EV purchase subsidies, where diminishing returns have set in, and how these insights can inform more targeted and efficient EV policymaking. By disentangling the actual impact of key schemes, the findings aim to support a more rational, evidence-based evolution of India's EV strategy.

Evolution and Evaluation Imperative: India's EV Policy Journey

Over time, as policies have expanded in scale and scope, they have played a crucial role in bridging the viability gap for EVs, helping them compete with internal combustion engine (ICE) vehicles by

[6] Panel data refers to observations collected across different vehicle segments and states over consecutive monthly time periods, allowing for analysis that controls for variation across both geographic regions and vehicle segments simultaneously.
[7] We discuss this further in Appendix 1.

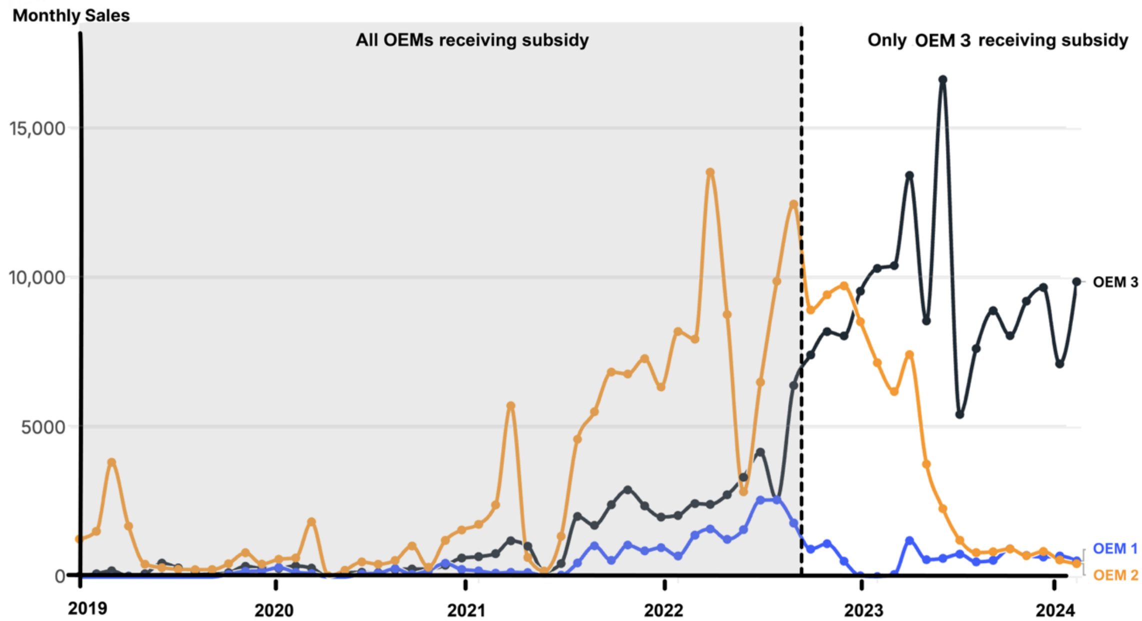
offsetting higher upfront costs and mitigating early-stage market risks. By addressing these cost disparities and creating a more level playing field, the government has ensured EV adoption is not constrained by market failures.

However, despite the central and state governments investing in EV promotion since 2014, there remains a gap in assessing whether this public expenditure has translated into proportionate returns in terms of vehicle adoption and market transformation. As India's EV ecosystem matures and newer initiatives like PM E-DRIVE adjust subsidy levels for segments demonstrating market traction, it has become imperative to evaluate policy effectiveness.

Our empirical evaluation was also triggered by our findings from a September 2022 event, when the Automotive Research Association of India audit revealed that some E2W manufacturers had failed to meet local sourcing requirements, resulting in their subsequent suspension from FAME-II benefits.[8] This enforcement action created a natural market bifurcation—manufacturers that are compliant, continued receiving subsidies, sustained their growth trajectory while those without subsidies experienced a significant decline in sales. We indicate this incident through an example of three manufacturers – OEM 1 and 2, whose subsidies were withdrawn and OEM 3 which is complaint and continued to receive subsidy (**Figure 3**). Although not formal statistical evidence, it presented anecdotal evidence offering insights into the outsized influence that subsidies can have on consumer demand. This raised a critical question: Is similar reliance on purchase subsidies uniform across all EV segments, or have certain segments already achieved sufficient market maturity to function effectively with reduced or eliminated subsidies? Answering this could enable more targeted allocation of limited resources and indicate the need for a broader, data-driven investigation into how fiscal incentives shape EV adoption across vehicle segments and geographies.

[8] Swarajya. FAME II Scheme Non-Compliance: Seven Electric Two-Wheeler Makers Asked to Return Rs469 crore to Government. 25 July 2023.

Figure 3: E2W Sales Comparison: Impact of FAME Subsidy Withdrawal



Source: VAHAN Dashboard, GoI; IEEFA Analysis

Literature Review: Critical Insights and Research Gaps

Despite growing global research on EV incentives, knowledge gaps persist in the Indian context. While existing studies offer insights into specific interventions or vehicle segments, there is a lack of comprehensive, data-driven evaluations that span multiple policies, geographies and timeframes. This study addresses that gap by quantitatively assessing the effectiveness of India's key EV policy levers using robust empirical methods.

International researchers have examined subsidy impacts in developed markets—Clinton et al (2019) assessed battery EV adoption incentives in the US, while Sheldon and Dua (2024) analysed the cost-effectiveness of EV subsidies across 23 countries[9,10] However, these studies primarily focus on electric cars, which dominate those markets. In contrast, India's EV transition is shaped by a broader and more diverse vehicle ecosystem making it essential to generate segment-specific insights.

India-focused research has explored various dimensions: Aravind et al (2020) analysed the environmental benefits of EV subsidies across vehicle segments, Sunitha et al (2023) reviewed non-fiscal state incentives and Shrimali (2021) compared various subsidy approaches, concluding that

[9] Journal of Environmental Economics and Management. Providing the Spark: Impact of financial incentives on battery electric vehicle adoption. Bentley C. Clinton and Daniel C. Steinberg. 31 August 2019.
[10] Transportation Research Part A: Policy and Practice 187: 104173. The dynamic role of subsidies in promoting global electric vehicle sales. Sheldon, Tamara L., and Rubal Dua. 2024

purchase incentives are most cost-effective.[11,12,13] Specific policy evaluations include Rokadiya et al (2016) on FAME-I's impact on total cost of ownership (TCO) and Kohli (2024) on FAME-II's effects on upfront costs for two-wheelers and passenger three-wheelers.[14,15]

Furthermore, some experts have analysed the impact of Indian EV subsidies on different vehicle segments and how policy uncertainty dented EV sales during certain periods.[16] They argue that to achieve a sustainable transportation future, consistent application of both central and state policies is essential.[17]

Our study empirically evaluates how fiscal incentives have shaped EV sales and adoption across multiple segments over the past decade. By quantifying their deployment-effectiveness, we provide insights into which policies have been most influential, where gaps remain, and how future interventions can be tailored to maximise impact. In doing so, we not only trace India's evolving EV policy landscape but also build a robust evidence base to inform future policy innovations.

[11] Journal of Resources, Energy and Development. Assessing the Impact and Cost-Effectiveness of Electric Vehicle Subsidy in India. Aravind Harikumar and Palak Thakur. 10 April 2020.
[12] International Council on Clean Transportation (ICCT). Comparative evaluation of non-fiscal incentives to promote electric vehicles across Indian states and union territories. Sunitha Anup and Zifei Yang. June 2023.
[13] Energy Policy. Getting to India's electric vehicle targets cost effectively: To subsidize or not, and how? Gireesh Shrimali. September 2021.
[14] ICCT. Hybrid and Electric Vehicles in India: Current Scenario and Market Incentives. Shikha Rokadiya and Anup Bandivadekar. December 2016.
[15] ICCT. Electric Vehicle Demand Incentives in India. Sumati Kohli. July 2024.
[16] The Ken. Dear EV subsidy planners, the data has a few questions. 3 December 2024.
[17] The Economic Times. The crucial role of state policies in accelerating EV adoption. 25 December 2024.

Impact Assessment: Policy Effects Across EV Segments

Our study employs a 10-year panel dataset (2014-23) with 21,526 monthly observations, covering EV policy interventions by all major states/Union Territories (UTs) and the Centre across five EV segments.[18] This extended timeframe allows us to assess the evolution of India's EV policy landscape, including FAME-I (2015-19), FAME-II (2019 onwards), PLI schemes and state EV subsidies.

Before discussing the results of our analysis, we introduce our key policy proxy variable, then outline our empirical methods and other variables used, and finally present segment-specific findings.

Key Policy Variable: Subsidy Intensity

A key methodological contribution in our analytical approach is the development of "Subsidy Intensity" (SI), a dynamic metric that captures the evolving relationship between government support and fluctuating EV prices. Unlike conventional studies that simply track whether a subsidy policy exists (present=1, absent=0) or use fixed subsidy amounts for cross-sectional analysis, SI quantifies the actual percentage of an EV's per-kWh price that is offset by government support at each point in our study period. This resembles how consumers evaluate promotional discounts while purchasing any product.

SI is constructed as:

$$Subsidy\ Intensity, SI\ = \frac{Subsidy\ per\ kWh}{Average\ Price\ per\ kWh\ of\ EV}$$

What makes SI valuable is its ability to capture temporal variations in policy impact. While subsidy amounts often remain fixed during a policy period, their effective discount percentage fluctuates as manufacturers adjust price in response to changing market conditions. SI effectively tracks this dynamic subsidy-to-price ratio, providing a more accurate picture of how the same policy exerts different levels of influence on consumers' purchase decisions throughout market development. A detailed discussion of the variable is presented in **Appendix 1.1.1**.

Empirical Framework and Control Variables[19]

To isolate the impact of overlapping central and state policies, we employ a two-pronged econometric approach:

[18] Discussed in Appendix 1.1
[19] Refer to Appendix 1.2

1. For central policies (FAME-I, FAME-II and PLI), we utilise panel regression with fixed effects, examining how different SIs are associated with EV sales and adoption rates while accounting for the relative operating cost of EVs, state-specific characteristics and broader economic trends. Our model captures the absolute growth in sales volumes and the relative market share measured by adoption rates—the percentage of total vehicle sales represented by electric options within each segment. This approach allows us to identify how increases in SI translate into market outcomes while accounting for critical factors like the relative operating costs of electric versus conventional vehicles and state-specific demographics.

The key relationship we investigate is expressed through our regression equation:

$$\boldsymbol{ln}\,(\boldsymbol{Y}_{\boldsymbol{s,e,t+1}}) = \boldsymbol{\alpha} + \boldsymbol{\beta SI}_{\boldsymbol{e,t}} + \boldsymbol{\gamma ln}(\boldsymbol{RelOC}_{\boldsymbol{s,e,t}}) + \boldsymbol{\delta X}_{\boldsymbol{s,t}} + \boldsymbol{\mu}_{\boldsymbol{s}} + \boldsymbol{\theta}_{\boldsymbol{t}} + \boldsymbol{\varepsilon}_{\boldsymbol{s,e,t}} \qquad \textbf{(1)}$$

where:

- $(Y_{s,e,t+1})$ is the dependent variable (either log of monthly EV sales or the EV adoption rate) for state *s*, segment *e*, in month *t+1*.
- $SI_{e,t}$: Central Subsidy Intensity in month *t* for segment *e*.
- $RelOC_{s,e,t}$: Relative operating cost of EVs vs ICE vehicles.
- $X_{s,t}$: Vector of time-varying state-level controls (per capita income, literacy rates, mean age).
- μ_s: State fixed effects; θ_t: Time fixed effects.
- Standard errors are clustered at the state level.

2. For state policies, most of which were introduced after FAME-II became operational, we employ difference-in-differences (DiD) and synthetic control methods (SCMs) to establish the causal impact of state policies on EV sales and/or adoption rate.[20] These two methods examine whether state EV subsidies, when combined with central support, generate a boost in local adoption beyond what central subsidies alone would have achieved.

To isolate the causal impact of state EV subsidies, we first employed propensity score matching (PSM) to address potential selection bias among states, followed by a DiD design, as represented in the below equation:

[20] The Difference-in-Differences (DiD) methodology establishes causal effects by comparing outcome trajectories between states that implemented policies (treatment group) and those that did not (control group), while accounting for baseline differences and broader market trends. This approach allows us to isolate the specific impact of state policies from other factors influencing outcomes, including central government initiatives.

$$\boldsymbol{ln(Y_{s,e,t+1}) = \alpha + \beta\,(Treat_s \times Post_{s,t}) + \gamma ln(RelOC_{s,e,t}) + \eta TotalCSI_{e,t} + \delta X_{s,t} + \mu_s + \theta_t + \varepsilon_{s,e,t}}$$
(2)

where:

- $Treat_s$: Dummy variable equal to 1 for states that implemented a subsidy policy and 0 for control states.
- $Post_{s,t}$: Dummy variable equal to 1 for periods after policy implementation and 0 for pre-policy periods.
- $TotalCSI_{e,t}$: Aggregated central subsidy intensity over time.
- Other terms as defined above

The coefficient β here represents the causal effect of state policies on EV sales or adoption, over and above central support. By disaggregating outcomes by segment and state, we provide insights into India's diverse EV transition. For DiD, as mentioned in equation (2), we include total central subsidy intensity (TotalCSI), an aggregate measure of central policy support over time, as a control variable. This variable captures the evolution of central government support: initially measuring FAME-I SI (2015-19), then transitioning to FAME-II SI (2019-22), and finally incorporating both FAME-II and PLI intensities from 2022 onwards. This measure allows us to track cumulative policy support while accounting for policy transitions and overlaps.

Second, we complement the DiD approach with SCM to strengthen our evidence of the causal impact of state purchase subsidies on EV sales and adoption rate.[21] We begin by identifying control states—those that did not introduce a subsidy within a ±24-month window of the treated state's policy start. From this set of control states, we construct a donor pool comprising states with similar pre-policy characteristics, matching on pre-policy sales trends, fuel costs and demographics. Building on this empirical foundation, we present our results disaggregated by vehicle segment.

A detailed discussion of data sources, variable construction, key assumptions and methodological robustness is provided in **Appendix 1**.

[21] For SCM, we present illustrative cases for early-mover states that introduced EV purchase subsidies ahead of most others. While our methodology ensures a clean donor pool by excluding states with overlapping or near-simultaneous policy interventions, focusing on early adopters enhances the credibility of the counterfactual by ensuring that control states were genuinely untreated during the pre- and post-policy windows. Similar SCM analyses have been conducted for other states as well and are available on request. SCM tests were validated using an in-time placebo test.

Electric Two-wheelers: FAME-II's 9x Multiplier and Multi-level Policy Impact

India's E2W market experienced a remarkable transformation between 2019 and 2023, coinciding with the FAME-II period. During this time, overall two-wheeler sales in India declined from 21.1 million units (in 2018-19) to 16.2 million units. In stark contrast to this, E2W sales surged from 19,333 units to 659,397 units during the same period. This growth translated to a significant increase in market penetration, with E2W adoption rates climbing from a mere 0.09% to 4.07%.

To move beyond simple correlation observations, we conducted regression analysis to statistically evaluate how government policies influenced this market evolution. Our analysis examined three key central initiatives—FAME-I, FAME-II and the automotive and battery PLI schemes—to determine their impact on E2W adoption patterns. The statistical evaluation reveals differences in how each policy contributed to market growth, allowing us to distinguish which interventions effectively accelerated E2W adoption in India.

During FAME-I, the government's modest ~Rs5,000 per kWh purchase subsidy translated to an SI of just 14.32%—the percentage of an EV's per-kWh price offset by the purchase subsidy. Our regression analysis indicates this level was insufficient to substantially stimulate E2W sales. Statistical evidence confirms this subsidy fell below some critical threshold needed to overcome initial market barriers.

FAME-II doubled the government subsidy to an average of Rs12,000 per kWh during the scheme period, thus increasing the SI to 28.65% compared with just 14.32% under FAME-I. This SI was likely critical in pushing prices below the psychological threshold that had deterred consumers from purchasing. We calculate the economic significance using a statistical relationship—when SI goes up by 5.4 percentage points, the sale of E2Ws increases by 12.7%.[22,23] This highlights an important economic and policy insight—SI or the discount offered through purchase subsidy needs to reach a minimum threshold percentage to effectively influence consumer behaviour. FAME-I's SI remained below this critical threshold, while FAME-II's SI successfully crossed it, explaining the dramatic difference in market outcomes between the two programmes.

Using the statistical relationship between SI and sales growth, we estimate that approximately 1.63 lakh E2Ws sold can be directly attributed to FAME-II subsidies. What is remarkable is the potential maximum market multiplier effect: while 1.63 lakh E2Ws were directly attributable to FAME-II subsidies, actual sales reached 14.4 lakh units during the policy period, implying a multiplier sales effect of up to 9x.[24] This 9x sales multiplier reveals how government support catalysed broader

[22] FAME-II SI Coefficient = 2.224 significant at 1% p-value.
[23] This 12.7% represents an average effect that can be interpreted both monthly and annually, particularly since SI tends to be sticky and typically adjusts based on the launch price of any new vehicle. Given this feature of SI variable, we apply this average effect at the annual level, multiplying the total yearly E2W sales by 12.7% for each standard deviation increase in SI.
[24] The detailed methodology and year-by-year calculations for this counterfactual analysis are presented in **Appendix 2**.

market forces, including increased consumer awareness, expanded model availability, and surging gig-economy demand, creating momentum beyond direct subsidy impacts. This can also be interpreted as exceptional policy leverage, where each rupee of policy-driven value spurred nearly nine rupees of total market creation.[25] In addition, this multiplier effect resulted in an estimated 2.8 million tonnes of CO_2e avoided over the lifetime of these vehicles.[26]

> ***FAME-II's higher SI (28.65%) compared to FAME-I (14.32%) successfully stimulated E2W market growth with up to a 9× multiplier effect on absolute sales, though it had limited impact on improving E2W adoption relative to conventional two-wheelers.***

A critical distinction emerges in our analysis: while FAME-II significantly boosted absolute E2W sales, it did not meaningfully increase the adoption rate—the percentage of E2W sales compared to total two-wheeler sales. This gap suggests that purchase subsidies alone, even at higher intensities, cannot transform overall market composition without complementary measures.

These findings align with Sheldon and Dua's 2024 research, showing that direct purchase incentives have immediate effects on EV sales, while highlighting the importance of policy design that extends beyond simple subsidy existence to carefully calibrated SI levels. While subsidies successfully boosted absolute E2W sales volumes, the adoption rate remained modest because India's two-wheeler market is distinctly segmented—EVs have primarily replaced conventional scooters, while the larger motorcycle segment has seen minimal electrification.

Recent data from April-November 2024 shows motorcycles hold a dominant 63% market share (8.78 million units) compared to scooters' 34% share (4.78 million units).[27] Even within the scooter segment, electric models account for only 10.49% of sales (502,165 units) during this period, despite growing demand. With manufacturers like TVS and Hero reporting about 15% EV penetration in their scooter lineups, and virtually no electric motorcycles on the market, the overall impact on two-wheeler market share remains limited despite significant absolute growth in E2W sales.

Our regression analysis found no statistically significant relationship between PLI subsidy intensity and E2W sales or adoption rates. Unlike demand side subsidies like FAME-I and FAME-II, the PLI scheme functions primarily as a supply-side intervention that targets domestic manufacturing capacity for batteries and auto components rather than directly affecting consumers. The absence of

[25] Refer to Appendix 2 for the underlying calculations.
[26] Assuming a 15-year vehicle lifetime, average daily travel of 30 km, petrol 2W emission factor of 39.04 gCO_2/km, EV electricity emission factor of 850 gCO_2/kWh, and EV energy use of 30 Wh/km.
[27] Autocar Professional. Scooter sales jump 21% in April-November, slower 10% growth for motorcycles. 14 Dec 2024

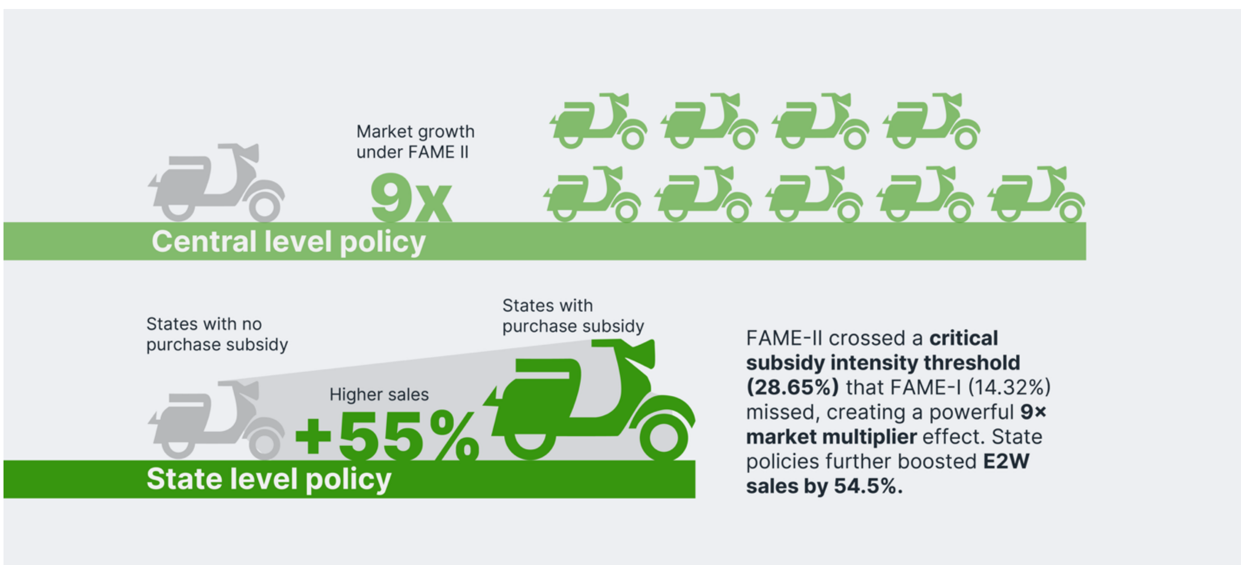
a statistically significant positive relationship between PLI subsidy intensity and monthly E2W sales suggests that manufacturing incentives operate through channels different from consumer subsidies, with potential benefits materialising over longer timeframes than what our analysis could capture for the E2W segment.

State policies further boosted E2W sales by 54.5%

Our DiD analysis establishes a causal relationship between state policy implementation and E2W market outcomes, after factoring in central purchase subsidies. The results demonstrate that state purchase subsidy policies generated a significant 54.5% increase in E2W sales volume compared to states where only central policies were in place.

> **States that implemented purchase subsidy policies witnessed an increase of 54.5% in E2W sales compared to those where such measures were not in place.**

Figure 4: E2W Policy Impact (Summary)



Source: IEEFA Analysis

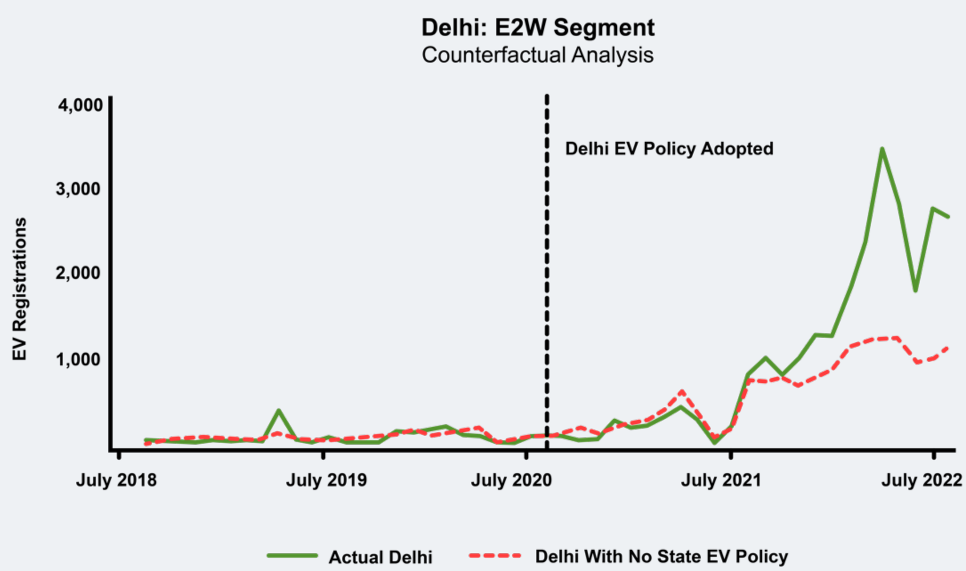
Despite this substantial increase in absolute sales, state policies had little impact on the E2W adoption rate. This mirrors our findings on central government policies, particularly during FAME-II, where higher SI boosted absolute sales without significantly changing the adoption rate.

This consistent pattern in both state and central interventions reveals an important limitation: while price incentives stimulate initial market growth, they appear insufficient for increasing adoption rate to a higher level, especially when there is a systemic issue of no electric motorcycle model availability. Despite the combined impact of state and central subsidies generating impressive sales growth, the overall E2W market share remains relatively low at around 4% by 2023 end.

These findings indicate that demand-side purchase incentives need to continue for the E2W segment until adoption rates reach sustainable levels where market forces can maintain momentum without government support.

Finally, we complement these findings using SCM to establish the causal relationship between state purchase subsidies and E2W sales. **Box 1** presents a case study on Delhi's E2W segment, with SCM analysis that reinforces our broader state-level evaluation findings of DiD.

Box 1: E2W Vehicles – The case of Delhi

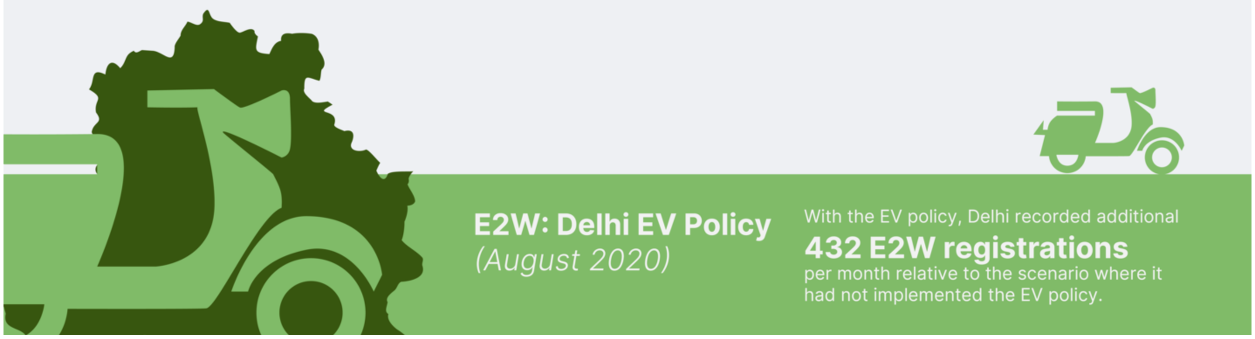


Our counterfactual analysis of Delhi's E2W segment reinforces the findings from our broader state-level evaluation. Prior to the August 2020 policy intervention (denoted by the vertical dashed line), the actual Delhi and synthetic Delhi registration trends closely align, demonstrating a strong pre-treatment fit over the 24-month period.[28] This suggests that the synthetic counterpart provides a credible counterfactual for comparison.

Post-policy, E2W registrations in Delhi began to consistently outpace the counterfactual. While the effect took a few months to materialise, the divergence became more pronounced over time. On average, Delhi recorded approximately 432 additional E2W registrations per month relative to the

[28] The synthetic trend represents the counterfactual trajectory of EV adoption in Delhi had it not implemented its EV policy. For details of the construction of the synthetic control, refer to Appendix 1.

synthetic scenario. It is important to note, however, that while this reflects a clear volume increase, it does not automatically imply a proportional rise in adoption rates, which depends on broader two-wheeler market trends.



Electric Three-wheelers (Passenger): FAME-I’s 10x Multiplier and Market Maturation

India’s E3WP segment experienced significant growth during FAME-I (2015-19), establishing a foundation for sustained market development.[29] This segment demonstrated unique responsiveness to early policy intervention compared to other EV categories.

During FAME-I, even modest subsidy support generated substantial market response in the E3WP segment, our regression analysis indicates. The statistical evidence confirms that for every 1.01 percentage-point increase in SI (equivalent to one standard deviation in SI for E3WP), the model predicts an 11.2% increase in E3WP sales. This relationship quantifies the sensitivity of the E3WP market to policy intervention during its formative stage.

Using this statistical relationship between SI and sales growth, we estimate that approximately 27,000 additional E3WPs can be directly attributed to FAME-I SI that would otherwise not have entered the market.[30] What is remarkable is the market multiplier effect: while these units were directly attributable to subsidies, actual sales reached 2.67 lakh by March 2019 (end of FAME 1), implying a sale multiplier effect of up to 10x. This indicates that for every E3WP unit statistically linked to SI, up to 10 units materialised in actual sales.[31] This can also be interpreted as every rupee of policy-driven value spurred nearly 10 rupees of market creation in the E3WC.[32] This multiplier

[30] FAME-I SI Coefficient equals 10.58 and strongly significant as indicated by 1% p-value.
[31] Considering the average unit value of Rs152,000 (calculated based on the typical average battery size of 6.82 kWh at Rs22,300 per kWh), the policy-driven market value amounted to Rs4,100 million, which generated a market value of over Rs40 billion from 2015 to March 2019.
[32] Refer to Appendix 2 for the underlying calculations.

effect resulted in an estimated 5.53 million tonnes of CO_2e avoided over the lifetime of these vehicles.[33]

In addition to the direct FAME-I policy impact, this multiplication was potentially driven by a combination of other unobservable factors in our model, including local regulatory enablers such as permit exemptions, entrepreneurial uptake for last-mile connectivity solutions, strong geographical penetration (even in smaller towns) and strong word-of-mouth effects once early adopters validated the business model.

The transition to FAME-II (2019-23) marked a shift in the market's maturity. While the scheme's direct impact appeared statistically insignificant, the market demonstrated robust growth and resilience with consistent year-over-year growth rates exceeding 40%. This indicates a significant structural transformation—what began as "category creation" during FAME-I had matured into a self-sustaining market, driven primarily by commercial demand rather than central subsidies.

> **FAME-I achieved sufficient SI for E3WP, creating a powerful 10× market multiplier effect that transformed into a self-sustaining commercial market during FAME-II, demonstrating how early-stage intervention can trigger structural transformation.**

The market's strength comes from simple economics. Operators prefer E3Ws even though they cost 55% more upfront than gasoline versions. Compared to natural gas models (the cheapest conventional option), E3Ws recover their extra cost within two years and end up about 40% cheaper over their eight-year lifespan.[34] Subsidies help speed up adoption by shortening this payback period—without them, operators would need to wait four years to break even, though the long-term savings are substantial.

These favourable economics in the E3WP segment are uniquely complemented by supply-side interventions. Unlike in the E2W market, our analysis shows that for E3WP vehicles, the auto PLI scheme positively influences market dynamics. This pattern aligns with the E3WP segment's market structure, which features a more diverse manufacturer base with numerous small and medium enterprises contributing to production, compared to the more consolidated E2W segment. E-rickshaws, which constitute the majority of the E3WP market, benefit from simpler drivetrains and less demanding performance requirements, resulting in lower manufacturing complexity and capital intensity. PLI support for this manufacturing ecosystem appears to enhance component localisation

[33] Assumes a 15-year vehicle lifetime, daily travel of 60 km (21,900 km annually), diesel 3W emission factor of 132.2 gCO_2/km, EV electricity emission factor of 850 gCO_2/kWh, and EV energy consumption of ~81.3 Wh/km
[34] Clean Mobility Shift. Success story: India is now the biggest electric 3-wheeler market in the world. 26 April 2024.

and production scale efficiencies, expanding model availability and improving affordability—advantages that have contributed to the segment's distinctive response to manufacturing incentives.

State policies had minimal impact on an already well-established E3WP segment

Our DiD analysis shows statistically insignificant effects of state policy implementation on E3WP market development. State policy shows a slightly positive but statistically insignificant impact on sales.

This limited impact of state policy can be understood through the timing of policy interventions. By the time states began introducing EV policies, FAME-I had successfully helped E3WP to capture the market. During FAME-I, the market demonstrated extraordinary growth rates, reflecting successful market catalysis in the segment's formative years. The timing of state interventions, coming after this crucial market establishment phase, likely had limited incremental impact.

Our SCM-based counterfactual analysis of the E3WP market, presented in **Box 2**, reinforces these findings, highlighting how market maturity and pre-existing adoption levels influence the effectiveness of subsequent policy interventions.

Notably, even FAME-II's higher purchase subsidies, introduced in April 2019, did not have a significant direct impact on sales or adoption rates, suggesting that the segment had evolved beyond being primarily driven by purchase incentives.

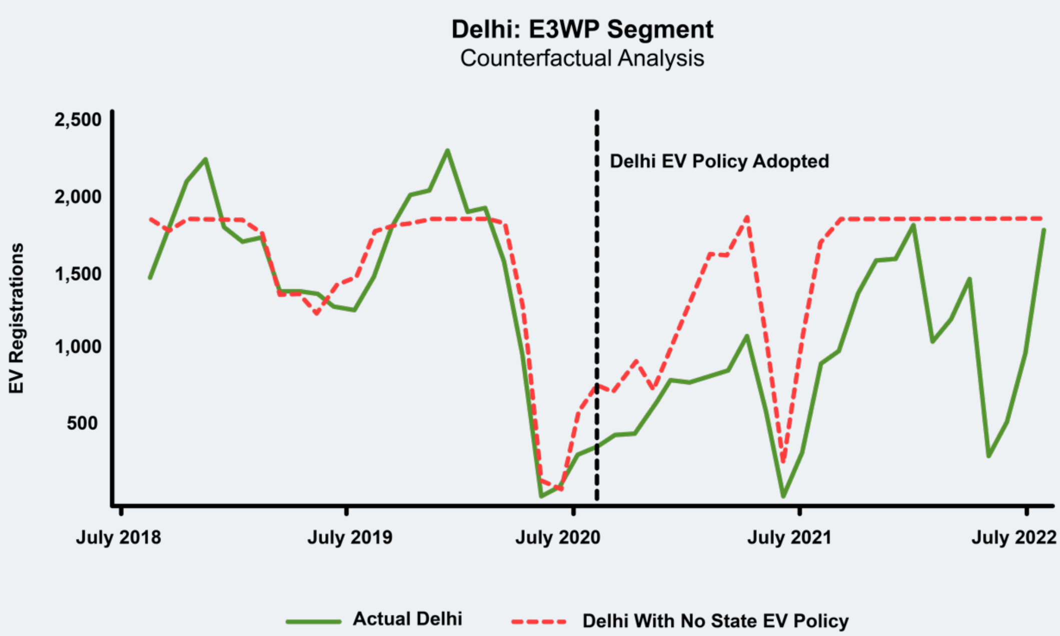
> **The E3WP market evolved beyond subsidy dependence after FAME-I, demonstrating successful policy-to-market transition where commercial viability rather than incentives were driving growth—an example of effective early-stage intervention creating sustainable market transformation.**

The market's transition from policy-dependent growth during FAME-I to market-led development is evident from its continued expansion despite the statistical insignificance of both state and FAME-II purchase subsidies. This suggests a fundamental shift in market dynamics, where commercial viability and business case strength have become more important than policy support.

Figure 5: E3WP Policy Impact (Summary)

Source: IEEFA Analysis

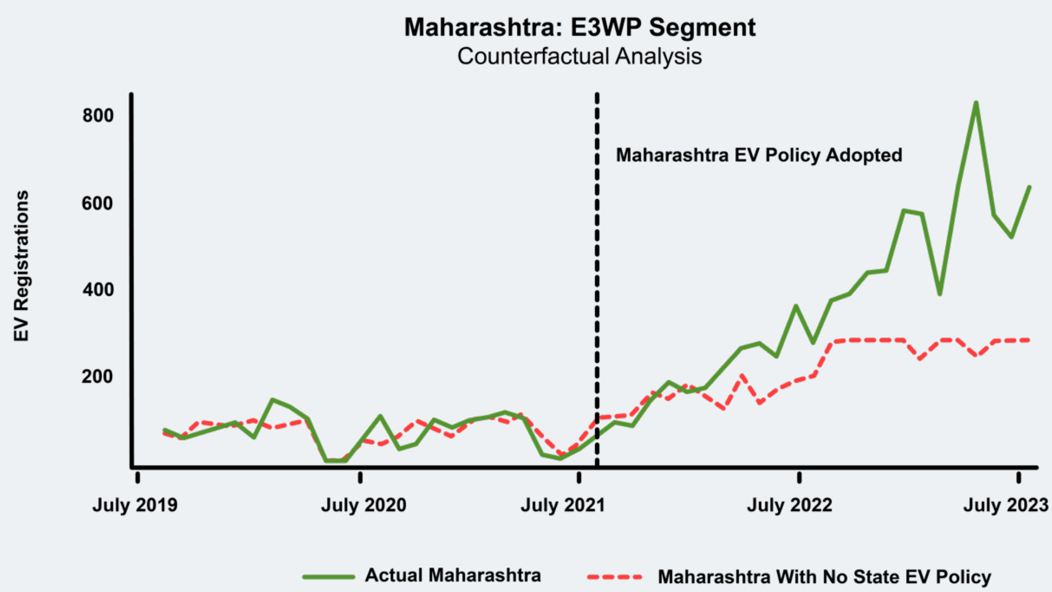
Box 2: E3WP vehicles – the case of Delhi and Maharashtra – transitioning from policy-driven to market-sustained model



Before Delhi introduced its EV policy in August 2020, it was already a national leader in E3WP sales, with monthly registrations ranging from 1,500 to 2,000 units. This high starting point reflects a relatively mature market. Accordingly, the synthetic counterfactual constructed from a weighted mix of less mature states that had not implemented active EV policies projects a steady growth trend, benefiting from base effects in states that were still in the early stages of adoption.

After the policy rollout and the easing of COVID-related disruptions, E3WP sales in Delhi rebounded. However, the rebound was modest compared to the sharper recovery observed in control states which make up the donor pool, which had more headroom to grow. As a result, Delhi's actual sales closely tracked or slightly underperformed in the synthetic scenario. This suggests that the impact of the EV policy was limited, not due to design flaws, but because Delhi might have already captured much of the low-hanging fruit in this segment.

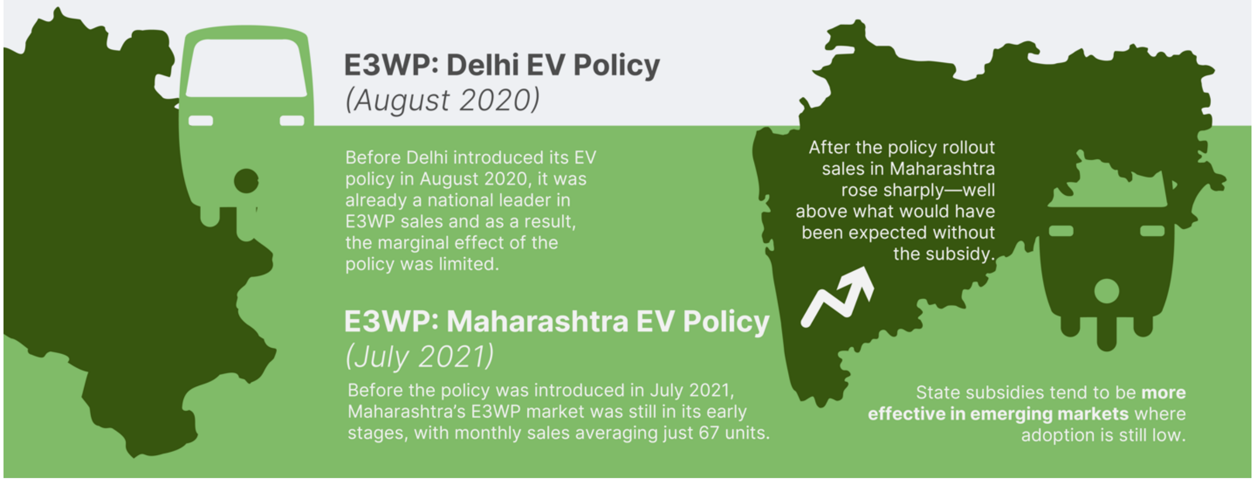
In essence, SCM results reaffirm that state policies have a stronger visible impact in emerging markets, whereas in mature segments like Delhi's E3WP market, additional subsidies yield diminishing returns.



In contrast to Delhi, our analysis shows that Maharashtra's EV policy had a clear and positive impact on E3WP sales. Before the policy was introduced in July 2021, Maharashtra's E3WP market was still in its early stages, with monthly sales averaging just 67 units. The synthetic counterfactual projects a modest growth path, but after the policy rollout, actual sales in Maharashtra rose sharply—well above what would have been expected without the subsidy.

This strong response reflects the fact that Maharashtra was starting from a low base, and the policy helped lower key cost barriers for early adopters. In newer markets like this, purchase subsidies can play a major role in jumpstarting demand.

This comparison highlights an important takeaway: state subsidies tend to be more effective in emerging markets where adoption is still low. In more mature markets, where EV demand is already established, non-monetary levers like financing support, charging infrastructure and operational incentives may have a bigger role to play.



Electric Three-Wheelers (Cargo): State Policy Impact and Economics-Driven Growth

The E3WC segment's evolution from 2015 to 2023 is an example of successful market transformation. While direct statistical linkage between FAME subsidies and sales growth or adoption rate appears modest in our regression analysis, the segment's dramatic market capture—from virtually non-existent (0.03%) to nearly one-third market share (31.04%)—tells a more nuanced story about policy effectiveness.

This disconnect between SI and E3WC sales and adoption rate suggests that factors beyond direct subsidies have played a fundamental role in driving adoption. While the statistical evidence for direct SI is weak, this does not necessarily indicate policy inefficiency. What it suggests is that the policy's role might have been more catalytic—helping create enabling conditions for market development rather than directly driving sales through subsidies. The evolution of the E3WC segment appears to be driven by fundamental market forces, particularly operational economics.

Our regression result reveals the pivotal role of operational costs in E3WC market performance. For every 1% decrease in operating costs of E3WC relative to corresponding ICE vehicles, E3WC sales increased by 0.563% while adoption rates increased by 0.167%, both statistically significant findings.

> **The E3WC segment demonstrates successful policy-to-market transition where initial catalytic interventions created conditions for economic advantages to drive sustained adoption—achieving significantly high growth in adoption rate.**

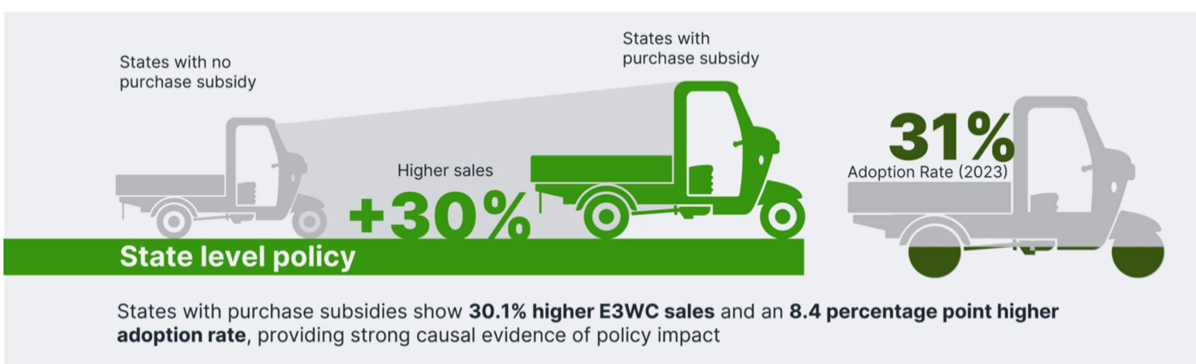
These results demonstrate that commercial operators prioritise purchasing decisions based on economic fundamentals like TCO rather than policy subsidies.

This cost sensitivity is particularly pronounced in the commercial segment, where energy expenses directly impact business profitability. The strong negative coefficients for relative operating costs provide compelling evidence that favourable economics have become the primary market driver, explaining the robust growth despite limited direct policy impact. Commercial operators are opting for EVs as operational advantages continue to improve compared to conventional vehicles.

Additionally, vehicles in the commercial segment are typically utilised for business purposes, allowing many operators to claim GST input tax credits. These tax benefits, available for all business-purpose vehicles rather than just EVs, further contribute to the favourable total cost of ownership that appears to be driving adoption decisions. While these tax advantages represent a significant factor in the decision-making process for fleet operators, they are not directly captured through any corresponding variables in our analysis.

The segment demonstrates clear signs of successful technology substitution, with electric variants steadily replacing ICE vehicles in commercial applications as is evident from the adoption rate. This transformation is noteworthy given the weak statistical evidence for policy impact, suggesting that market forces have become self-sustaining. The progression from negligible market presence to significant market share indicates the successful market integration of electric alternatives in commercial applications.

Figure 6: E3WC Policy Impact (Summary)

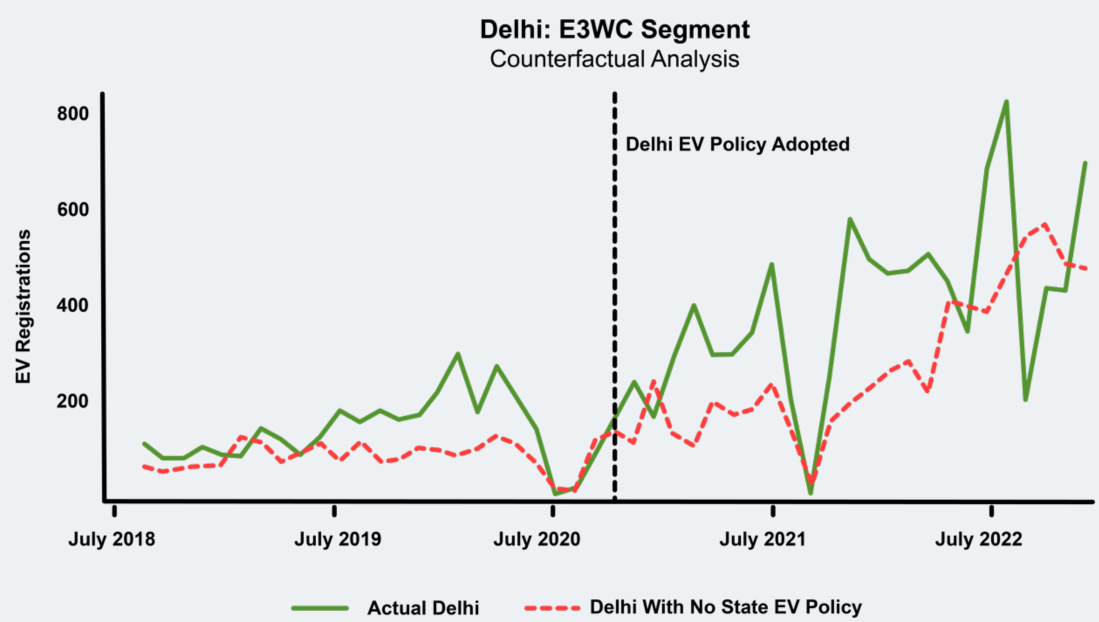


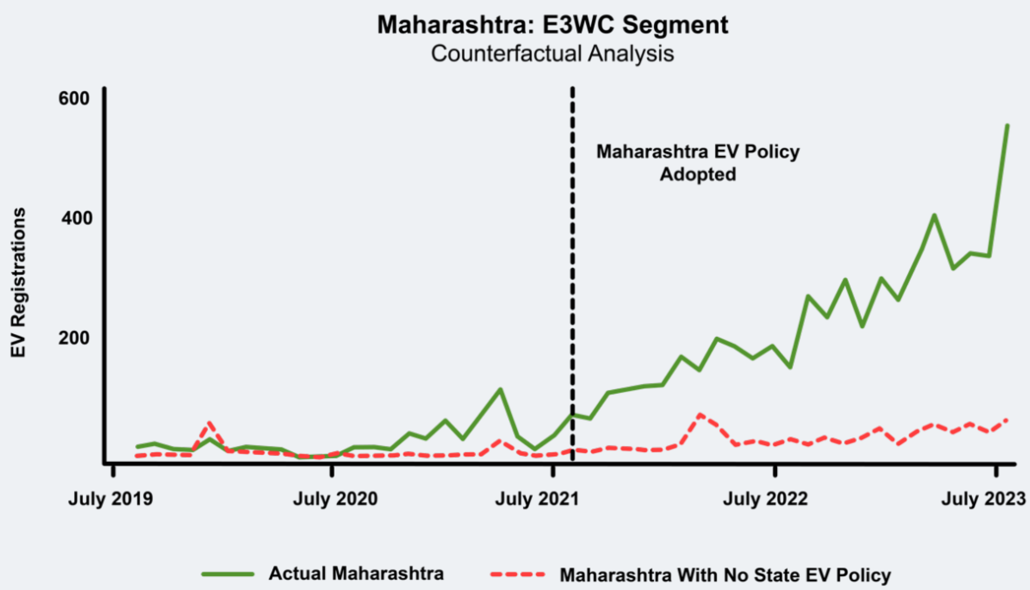
Source: IEEFA Analysis

State Subsidies and Favourable Operating Economics: Dual Drivers of E3WC Growth

Our DiD analysis revealed positive and statistically significant causal effect of state purchase subsidy on E3WC market development. States implementing these policies show 30.1% higher sales of E3WC compared to states without such policies. We find significant causal evidence of policy impact on adoption rates, with states having policies showing 8.4 percentage points higher adoption rate compared to states without policies. The SCM-based counterfactual analysis presented in **Box 3** corroborates these findings, demonstrating a strong market response to state policy interventions in the E3WC segment.

Box 3: E3WC vehicles - Delhi vs. Maharashtra – the crucial role played by state policies

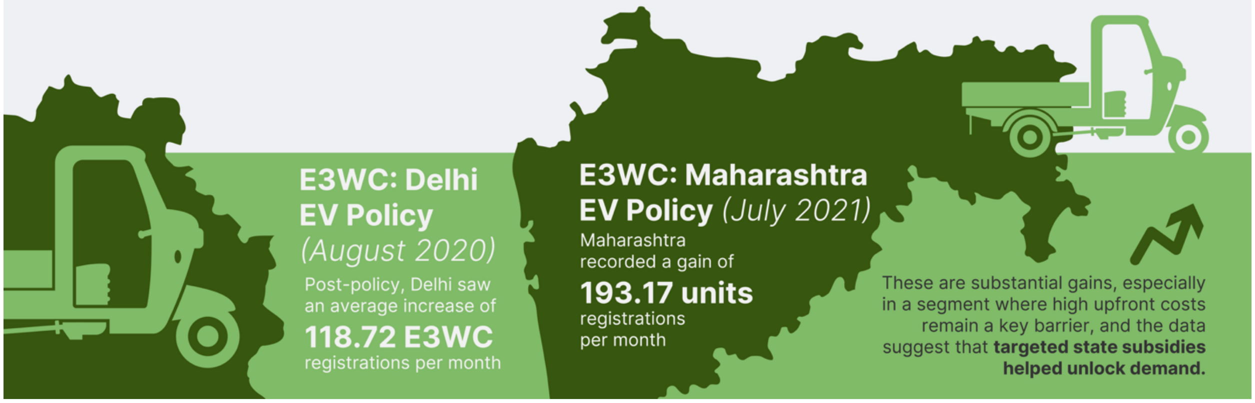




Our analysis of Delhi and Maharashtra's E3WC segments reinforces our DiD and panel regression findings, highlighting the positive response of E3WC to state policies. Prior to policy implementation (denoted by the vertical dashed line), both Delhi and Maharashtra exhibited a strong pre-treatment fit with their synthetic control counterparts, demonstrating similar trends. The counterfactuals provide a credible baseline, though in Delhi's case, the counterfactual had lower historical E3WC sales, causing Delhi's actual sales to occasionally exceed its counterfactual even before the policy intervention. Despite this, the trend remains aligned, indicating a reliable pre-policy match. Similarly, Maharashtra's pre-policy movement closely tracks its counterfactual, validating its credibility.

Post-policy, both Delhi and Maharashtra exhibited a clear and sustained upward divergence from their synthetic controls. Delhi saw an average increase of 118.72 E3WC registrations per month, while Maharashtra recorded a gain of 193.17 units. These are substantial gains, especially in a segment where high upfront costs remain a key barrier, and the data suggest that targeted state subsidies helped unlock demand.

These findings align with the panel regression results, which showed a strong positive correlation between state SI and E3WC sales and adoption rates. The results also underscore that the E3WC segment's transition to a commercially viable market has been supported by state interventions, particularly in states that introduced targeted purchase incentives. While FAME-II had a limited direct effect on E3WC adoption, these results suggest that state policies were instrumental in sustaining growth momentum in this segment by effectively making it cheaper to transition to E3WC.



These findings are strengthened by our panel regression analysis, which demonstrates substantial positive impacts of state SI. To put this in economic significance terms, an increase in state SI (one standard deviation of 27.74%) leads to a 46.16% increase in E3WC sales and a 9.26 percentage point increase in adoption rate.

The strong positive response to state policy intensity is noteworthy given the context of FAME-II's limited direct impact. This suggests that state support plays a crucial role in market development by helping overcome critical price thresholds that remain even with existing central support. The significance of state policy becomes more apparent considering the E3WC segment's relatively higher price points, primarily driven by larger battery sizes compared to its passenger variants (passenger e-rickshaws).

The relationship between state policy intensity and market outcomes indicates that well-designed state support can effectively complement central initiatives. This is especially relevant for the E3WC segment, which was in the early stages of market development when most state policies were implemented, unlike its more mature passenger counterpart. The segment's transformation from merely 18 units in 2015 to 1,246 by the end of FAME-I (March 2019) and to 62,348 units (signifying an adoption rate of 31%) by December 2023 reflects this policy-supported evolution.

Electric Four-Wheelers (Commercial):[35] Policy Synergy Driving Growth Amid Persistent Barriers

Our analysis reveals a progressive improvement in policy effectiveness across different central initiatives targeting the E4WC segment:

FAME-I (2015-March 2019) demonstrated limited effectiveness. Annual sales remained below 700 units with adoption rates stagnating at 0.01%. This weak response likely stemmed from insufficient subsidy levels relative to high upfront costs and strong competition from CNG alternatives in commercial applications.

FAME-II (post-March 2019) marked a significant positive shift as evidenced by the strong association of SI with the sales and adoption rate.[36] Market acceleration became evident as sales jumped from 959 units in early 2019 to 40,000 units in 2023, with adoption rates improving from 0.02% to 0.90%. A one-standard-deviation increase (equivalent to 2.07% of average SI during the FAME-II period) in SI corresponds to an approximately 5% increase in sales. Using this relationship to calculate counterfactual sales, we estimate that of the 68,000 units[37] sold during FAME-II through 2023,[38] approximately 3,300 units can be directly attributed to FAME-II's subsidy effect.

This indicates a maximum market multiplier effect of 21, suggesting that for every E4WC statistically attributable to FAME-II subsidies, up to 21 additional vehicles materialised in the market. This could also be interpreted as highly exceptional policy leverage, where each rupee of policy-driven value catalysed nearly 21 rupees of total market creation.[39]

Furthermore, we also find a strong impact of relative operating cost of E4WC to that of the corresponding ICE vehicle. Our analysis indicates that a 1% decrease in relative operating cost leads to an approximately 4.5% increase in sales and a 0.097 percentage point increase in adoption rate. This strong cost sensitivity confirms that economic parameters are crucial drivers in commercial EV adoption decisions. A similar relationship observed in E3WC vehicles reinforces that cost economics fundamentally drive commercial EV uptake.

Next, the introduction of PLIs (for both automotive and battery manufacturing) shows the strongest positive impact, as observed with significant market expansion—sales surged from 18,585 units in 2022 to 40,000 units in 2023, with adoption rates reaching 0.90%.[40] This strong response suggests

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[35] Includes only commercial cabs. Refer to Appendix 1.3 for a discussion on this aspect.
[36] FAME-II SI showed substantially stronger effects with a coefficient of 2.397 for sales (significant at 1% level, t-statistic: 3.99) and 0.296 for adoption rate (significant at 1% level, t-statistic: 6.81).
[37] We estimate commercial four-wheeler EV sales by assuming they accounted for an average of 30% of total four-wheeler EV sales based on data from the Vahan dashboard.
[38] Resulting in achieving an estimated 0.65 million tonnes of CO_2e avoided over the lifetime of these vehicles assuming a 15-year vehicle lifetime, daily travel of 40km (14,600km annually), petrol 4W emission factor of 179.94 gCO_2/km, EV electricity emission factor of 850 gCO_2/kWh, and EV energy consumption of ~160 Wh/km.
[39] Refer to Appendix 2 for the underlying calculations.
[40] PLI showed the strongest positive impact (coefficient: 5.064 for sales, and 1.33 for adoption rate both significant at 1% level).

that addressing supply-side constraints through manufacturing incentives has been particularly effective for the E4WC segment.

> ***Commercial EV policies demonstrate powerful economic leverage, with a 1% decrease in relative operating costs driving 4.5% sales growth and FAME-II SI creating a 21x market multiplier effect that increased adoption from 0.02% to 0.90%. Yet, this still-low penetration rate warrants continued purchase subsidies.***

Overall, despite this growth, the 0.90% adoption rate by 2023 highlights persistent barriers. The commercial segment faces specific challenges:

- Strong competition from CNG vehicles offering established operational economics, especially in the sedan segment
- Higher upfront costs despite subsidies
- Fleet operators' sensitivity to TCO[41]
- Limited dedicated fast-charging infrastructure for commercial operations

State incentives positively affected E4WC sales

The empirical analysis of state policy impact on E4WC adoption reveals powerful synergistic effects between state and central policies. Our DiD analysis demonstrates a strong causal impact of state policies, showing states with EV subsidies experienced approximately 211% higher (three times) sales compared to states without such incentives.[42] This substantial differential highlights that state support plays an important role in uptake by helping overcome critical price thresholds, helping to close the significant upfront cost gap that deters EV adoption. These findings are further supported by SCM results **(Box 4)**.

However, despite these positive policy impacts, overall sales numbers for electric cars remain low compared to conventional vehicles with an AR just below 1% by the end of 2023, suggesting that while policy support helps, significant barriers to mass adoption persist.

[41] An ICCT study indicates that over an eight-year TCO period, CNG vehicles remain the most cost-effective option in the sedan segment, whereas EVs achieve TCO parity more favourably in the hatchback category. However, despite this, hatchbacks are rarely the preferred choice for EV taxis. Since EVs are a relatively new entrant in the taxi market, they are positioned as semi-luxury options. As a result, the segment has largely gravitated towards sedans and SUVs, which offer better passenger comfort and align with consumer expectations in the premium mobility space.

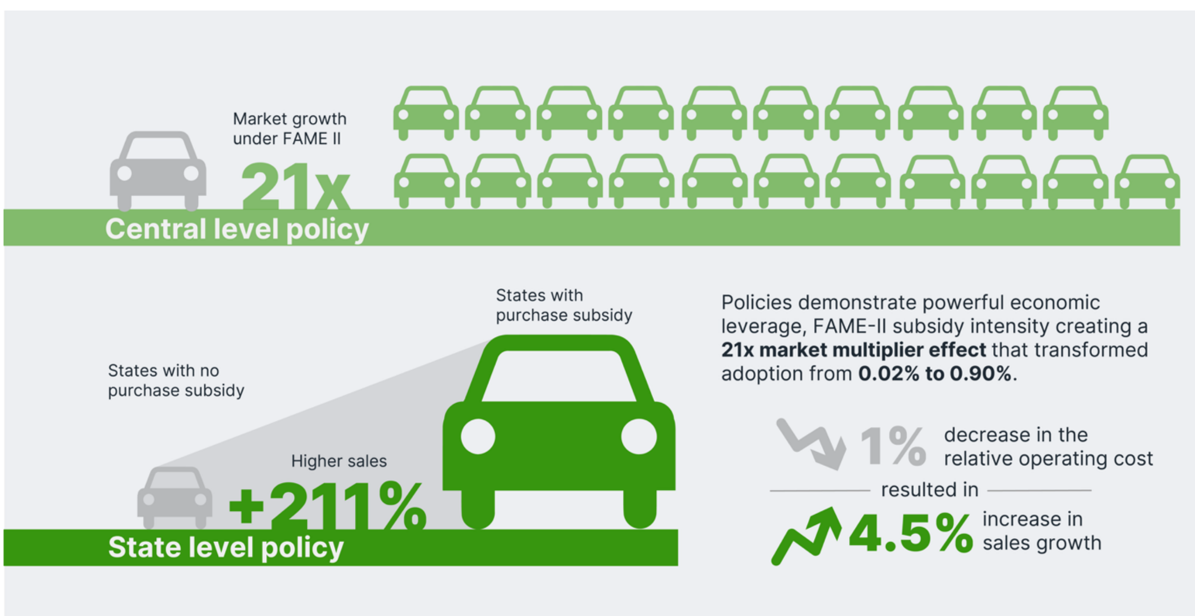
[42] DiD coefficient i.e. TREAT dummy interacted with post-policy implementation period dummy equals to 1.133 (significant at 1%), adoption rate also shows small but significant positive effect (0.001, significant at 5%).

> *State subsidies have a powerful impact on commercial EV markets, with states offering incentives experiencing 211% higher sales.*

Given that the current PM E-DRIVE scheme excludes electric cars, and state subsidies alone are unlikely to close the significant price gap, there is a pressing need for targeted national policies to address critical cost thresholds in this segment. Our analysis shows that E4WC sales have demonstrated strong sensitivity to subsidies, with significant increases in adoption. With passenger cars projected to become the largest contributors to transport emissions by 2030, a coordinated approach, led by the central government is essential.

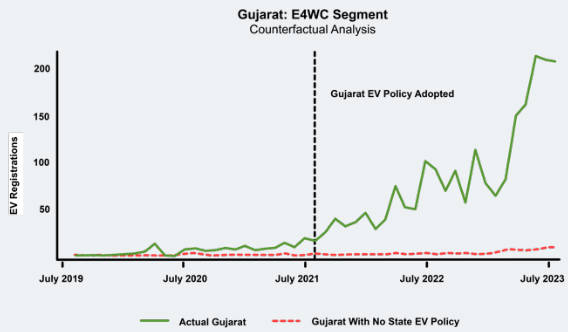
Central incentives, especially for commercial fleets, can unlock scale and send strong market signals. Meanwhile, states can play a complementary role by focusing on enabling measures such as concessional financing, and other targeted fiscal and non-fiscal incentives. But without strong central leadership, fragmented state-level efforts may fall short of catalysing a meaningful transition in this high-impact segment.

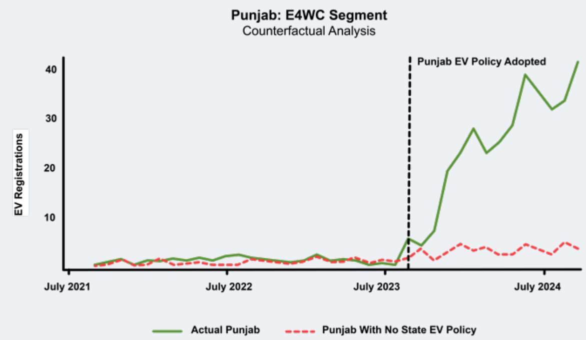
Figure 7: E4WC Policy Impact (Summary)

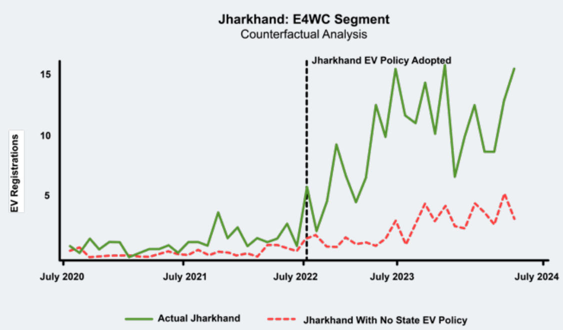


Source: IEEFA Analysis

Box 4: E4WC vehicles – Role of state policy-driven growth in Gujarat, Jharkhand and Punjab







Our analysis of the E4WC segment suggests that state incentives had a positive impact on sales. Since FAME-II exclusively supported commercial four-wheelers while most state policies extended support to both private and commercial E4Ws, we focus solely on E4WC sales to construct our counterfactuals. This approach helps isolate the combined effect of central and state subsidies, under the assumption that fleet operators would access both where available.

Across Gujarat, Punjab and Jharkhand, we observe a clear post-policy divergence between actual sales and their synthetic counterparts—pointing to the role of state incentives in catalysing E4WC market growth. The red lines in the graphs above can also be interpreted as a reference scenario: it reflects how sales might have evolved with only central policies in place.

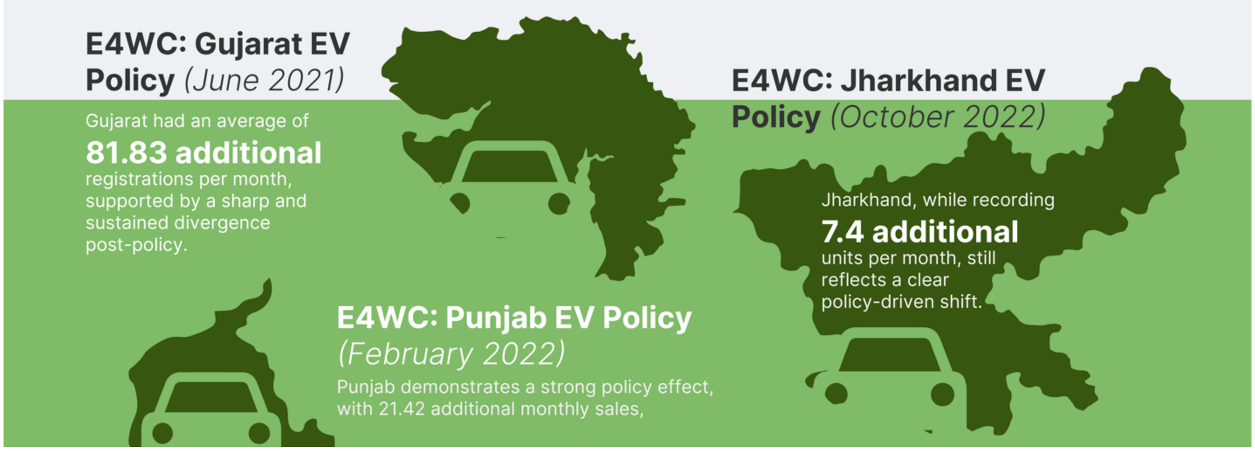
- Gujarat shows the most pronounced response, with an average of 81.83 additional E4WC registrations per month, supported by a sharp and sustained divergence post-policy. This aligns with the state's broader leadership in EV adoption.

- Punjab demonstrates a strong policy effect, with 21.42 additional monthly sales, and a tightly matched synthetic control during the pre-policy period, reinforcing the robustness of the estimate.
- Jharkhand, while recording the smallest absolute gain (7.4 additional units per month), still reflects a clear policy-driven shift, especially notable given its small market size and earlier stage of EV adoption.

In all three states, pre-policy trends closely match their synthetic counterparts, with only minor deviations due to early adoption variability. These gaps are minor compared to the consistent and significant divergence observed after policy implementation. This reinforces the causal link between state subsidies and adoption.

While the absolute increases are smaller than those seen in two- and three-wheeler segments, this reflects the structure of the E4WC market, where uptake is generally slower due to higher upfront costs, limited use cases, and financing constraints. Nevertheless, the results underscore that state subsidies played a complementary and catalytic role alongside FAME-II (which alone may not have shown greater results as seen from the red line), helping to reduce costs and accelerate fleet adoption.

Looking ahead, however, financial incentives alone may not be sufficient. To further scale up E4WC adoption, states may need to pair subsidies with non-monetary enablers, such as targeted financing instruments, robust public charging infrastructure, and regulatory measures like clean fleet mandates or fuel efficiency standards.



Electric Four-Wheelers (Private): Sales Growth Despite Waning Subsidies

Electric cars for private use constitute a significant share (~70%) of the overall E4W segment. Since 2014, the market has undergone a remarkable transformation, driven by government policies, technological advancements, consumer demand, and infrastructure development.

Early Years: FAME I (2015-2019)

During the FAME I period, the E4W market was in its nascent stage, characterized by limited model availability, low consumer awareness, and annual sales of fewer than 2,000 units. The price differential between an E4W and its internal combustion engine (ICE) counterpart exceeded ₹300,000, making affordability a key barrier.

Sales during this phase were predominantly driven by government procurement for use in central and state departments. While FAME I included a purchase subsidy for E4Ws, these incentives were largely directed toward commercial electric four-wheelers (E4WC) and government-use vehicles, rather than private buyers.

Expansion Phase: FAME II and Policy Shifts (2019-2022)

FAME II introduced a purchase subsidy of ₹10,000 per kWh, capped at ₹150,000 per vehicle, provided the ex-factory cost did not exceed ₹1.5 million. However, the allocated budget primarily supported E4WC, with no recorded disbursements for private-use E4Ws (E4WP).

Despite this limitation, other incentives—such as tax deductions on interest for EV loans (Section 80EEB) and state-level purchase subsidies in Delhi, Maharashtra, and Gujarat—helped drive adoption after 2019.

Market Acceleration: 2020-Present

The introduction of next-generation electric cars and popular models from Tata Motors, MG Motor, Mahindra & Mahindra, and Hyundai significantly boosted sales. By FY2023, annual E4W sales reached 90,000 units—double the previous year's figures. However, the adoption rate remains at a meagre ~2% by the end of 2024.

While some states continue to offer registration and road tax exemptions, others—such as Karnataka, Tamil Nadu, and Telangana—have phased out purchase subsidies for private buyers. Currently, a major federal incentive is the reduced GST rate for E4Ws (5%), compared to the 18-28% applicable to ICE cars.

Despite tracking these market developments in the private electric car segment, we excluded E4WP from our policy effectiveness assessment for several methodological reasons. First, India's FAME and state EV schemes have directed purchase subsidies predominantly toward commercial vehicles, with minimal support for private passenger cars. Second, the E4WP market presents significant analytical challenges—premium electric cars represent a substantial segment operating under market dynamics largely independent of FAME incentives. Their inclusion would have skewed our analysis, as their sales growth stems primarily from consumer preferences, and other indirect benefits rather than direct purchase subsidies. By narrowing our focus to commercial E4Ws, we established a more methodologically sound framework that allows for clearer isolation of policy impacts across both FAME phases, yielding more reliable conclusions about subsidy effectiveness.

Electric Buses: Policy Ambitions vs. Limited Market Traction

Under FAME-I, e-buses were nominally eligible for large purchase incentives—up to Rs3-4.1 million (US$45,000–61,500) per bus. Despite these high subsidies, the e-bus component of the allocated funds (Rs15,500 million in FY2015-16) was not effectively utilised. Most FAME-I subsidies went to passenger electric car hybrids (59%) and E2Ws (19%).[43] A few pilot demonstrations occurred—e.g., in Navi Mumbai—but not as a direct result of FAME-I’s standard mechanism. High upfront costs, unclear procurement rules, weak financial health of state transport undertakings (STUs) and limited local e-bus assembly hindered a full-scale rollout. Hence, FAME-I set a policy precedent of high e-bus subsidies but failed to generate any significant e-bus market momentum.

When FAME-II was launched, e-buses remained a priority in per-kWh terms (Rs20,000/kWh, capped at 40% of the ex-showroom price), with a target of 7,262 e-buses (originally 7,090, revised in early 2024). Key provisions under FAME-II included:

- Demand incentives for e-buses used in public transport or commercial fleets.
- A requirement that e-buses be procured predominantly via the OPEX/gross cost contract (GCC) model, wherein STUs pay operators on a per-kilometre or monthly basis.

While these measures led to some real deployments (e.g., the “Grand Challenge” tender for 5,450 e-buses via CESL), final data from the scheme revealed:

- 4,766 e-buses were subsidised, achieving ~66% of the revised target.
- E-buses made up about 4% of total bus sales in FY2023-24, indicating limited uptake compared to conventional buses.

Despite these policy mechanisms and the modest growth in deployment numbers, our empirical analysis sought to determine whether these interventions demonstrated a measurable causal impact on the market. We found no statistically significant positive effect of any central or state policy on e-

[43] ICCT. Hybrid and Electric Vehicles in India: Current Scenario and Market Incentives. Shikha Rokadiya and Anup Bandivadekar. December 2016.

bus sales or adoption rates. Multiple factors might explain why statistically insignificant or negative coefficients emerged.

First, most subsidies under FAME-II were channelled through large public procurement tenders involving STUs, particularly under the GCC model. These aggregated demand mechanisms are useful for scaling, but they do not necessarily reflect disaggregated, organic market demand or independent operator decision-making. As such, registrations from tender-led deployments may be weakly correlated with market-level price signals or unit-level subsidy intensity, making it difficult to detect policy effects in regression models that rely on such variation.

Second, most of India's ~2 million registered buses serve private inter-city or tourist routes, while less than 7% are publicly owned and operated by STUs. This limits the reach of policies that rely on STUs as the primary channel of deployment. Even within STUs, financial constraints, procurement delays, and capacity limitations have slowed the rollout.

Third, high upfront costs and limited financing options continue to constrain adoption. Even after FAME-II subsidies, e-buses are often 2-3 times more expensive than comparable diesel buses. Smaller private operators, who make up the majority of the sector—struggle to access long-tenure, low-interest loans that could offset this cost differential.

Fourth, operational complexity and lack of enabling infrastructure remain major hurdles. While depot-based charging is feasible for intra-city STUs, inter-city or regional operations require corridor-based fast charging, reliable electricity supply, and multi-jurisdiction approvals—factors not fully addressed by existing policies.

Thus, while absolute e-bus numbers grew somewhat under FAME-II, no clear empirical link emerged between the policy's demand incentives and adoption rates. This is reminiscent of concerns highlighted by Sheldon and Dua, who suggest that direct subsidies do not always ensure higher sales or adoption unless complementary measures are in place.[44] The dominance of ICE vehicles suggests that more robust infrastructure and policy frameworks are required for a widespread transition.

[44] Sheldon, Tamara L., and Rubal Dua. "The dynamic role of subsidies in promoting global electric vehicle sales." *Transportation Research Part A: Policy and Practice* 187 (2024): 104173.

Strategic Roadmap: Segment-Specific Policy Recommendations

India's EV sector is expanding fast on the back of government incentives and better cost dynamics. However, gaps remain when it comes to financing, infrastructure and domestic manufacturing. State subsidies have become important, especially since subsidies from the Centre have started to dwindle. Overall, sustaining long-term growth requires the Centre, state and industry to work in tandem.

Electric Two-wheelers: Sustaining Momentum Through Ecosystem Development and Policy Continuity

India's E2W industry has come a long way, from selling 1,679 units per year in 2014 to registering 6,59,397 units in 2023, a nearly 400x increase in nine years. While there were ups and downs in annual sales in this period, the trajectory was largely upward moving, driven by continuous policy impetus and improving economics of owning an E2W. However, while absolute sales numbers have witnessed a healthy increase, the adoption rate of E2Ws remained a modest 4.07% by 2023—a reasonable achievement when compared to countries such as Indonesia at about 1% and Vietnam at about 2.3%, but low compared with the market leader, China, at more than 30%.[45] To achieve India's vision of 30% EV sales penetration by 2030 in the E2W segment, India should:

- **Expand Support beyond Purchase Subsidies:**
  Improve the usability and attractiveness of E2Ws by investing in reliable public charging infrastructure, particularly in high-density urban zones. At the same time, address consumer concerns around battery life, resale value, and long-term maintenance to boost confidence in EV ownership.
- **Provide Policy Certainty with Phased Subsidy Tapering:**
  Continue offering purchase subsidies to sustain momentum but clearly communicate a phased-down trajectory. This will help consumers and manufacturers plan better, while nudging the market towards cost parity and self-sufficiency.
- **Strengthen State-level Support:**
  State governments should complement central schemes through targeted fiscal and non-fiscal incentives such as road tax waivers, permit exemptions, and designated EV zones that can lower the total cost of ownership and accelerate adoption at the local level.

[45] Adoption rates in other countries sourced from various industry and news reports.

Electric Three-Wheeler Passenger: Sustaining Market Leadership

With India accounting for 60% of global E3W sales in 2023, the E3WP segment has moved beyond the need for simple purchase subsidies.[46] Lessons from FAME-I confirm that early subsidies help catalyse emerging markets, but relying on direct incentives diminishes once the business case is proven. Going forward, policy focus should shift towards sustainable market enablers:

- **Financing Ecosystem over Subsidies**
  Specialised loans and leasing products for E3WP operators need to be encouraged. Special low-cost credit lines may be provided to non-banking financial companies lending to E3WP vehicles. Collaborations between financiers, manufacturers and Urban Local Bodies can facilitate structured financing mechanisms that reduce credit risks, encourage formalisation, and provide financial security to small fleet operators and independent drivers.
- **Strengthen Supply Chains and Manufacturing:**
  The success of PLI schemes in boosting local production (95% of components domestically made) underscores the importance of supply-side support. Domestic production of critical components (battery packs, power electronics) at quality standards is important to maintain consumer trust and decrease imports.
- **Regulatory Innovation and Urban Integration:**
  Municipalities should formalise e-rickshaw routes, parking zones and charging hubs, turning informal growth into streamlined feeder services. Local governments can replicate successful permit models to avoid congestion and ensure stable earnings for drivers.
- **Comparing E3WP needs with PM E-DRIVE:**
  PM E-DRIVE (October 2024-March 2026) continues to provide E3W subsidies, but E3WP has largely moved beyond heavy purchase-incentive dependence. Any upcoming interventions should focus on bridging financial-access gaps of OEMs and supporting advanced manufacturing, rather than large-scale buyer subsidies. Early data collection on E3WP uptake under PM E-DRIVE will help determine if additional targeted interventions are needed.
- **Role of States:**
  - Complement Central Ecosystem Approach: States can optimise local regulation (streamlined permits, designated EV zones) rather than layering broad subsidies on segments nearing self-sufficiency.
  - Promoting Low-cost Sub-national Finance: NBFCs play a central role in EV financing, but face a high cost of capital, raising interest rates for end users. States can reduce this burden by creating an NBFC consortium with access to derisked, low-cost funds.
  - Geographical Outreach: Rural and under-penetrated areas might benefit from targeted state programmes (e.g., aggregator-based financing or income-based support).

Overall, market-led expansion now drives E3WP growth, with purchase incentives playing a diminishing role. Strengthening financing, local manufacturing and urban integration can help the

[46] Clean Mobility Shift. Success story: India is now the biggest electric 3-wheeler market in the world. 26 April 2024.

segment achieve greater scale and quality without reverting to broad-based subsidies. As the new PM E-DRIVE programme takes effect, policymakers should track real-world uptake data for E3WP vehicles and pivot to focused structural measures if the market's self-sustaining trajectory continues.

Electric Three-Wheeler Cargo: Consolidating Economics-Driven Growth

The E3WC segment has witnessed remarkable growth in the last nine years, with the adoption rate going up from 0.03% in 2015 to 31.04% in 2023. However, this growth appears to be predominantly driven by factors other than direct subsidy, given the limited statistical evidence of a direct policy impact. Regardless, direct subsidies could have played a catalytic role in creating enabling conditions for market development.

Even as operational economics and other market forces continue to drive E3WC sales, we suggest the following policy interventions:

- **Gradual Policy Transition:**
  As E3WC shows strong market viability, policymakers should phase down direct subsidies predictably rather than abruptly. A gradual approach allows time for cost spillovers (e.g., from domestic battery manufacturing) to solidify. Under PM E-DRIVE, E3WC subsidies continue, but the scheme significantly reduces per-kWh incentives over time, which our empirical results also suggest. However, monitoring cost trends and sales or adoption rates will be critical to ensuring that scaling back does not stall the segment's momentum.
- **Infrastructure and Financing Focus:**
  - E3WC fleets can benefit from dedicated charging infrastructure beyond city centres and at key logistics hubs.
  - Given the clear TCO advantages, expanding specialised financing for small operators can reduce upfront costs, especially in underpenetrated areas.
- **Complementary State Interventions:**
  - In fiscally feasible cases, states may consider targeted support for specific use cases, such as E3WCs with larger batteries operating in last-mile delivery or cargo services.
  - More importantly, states can play a non-fiscal facilitative role by streamlining route permitting, establishing dedicated EV zones, and partnering with banks or NBFCs to lower credit risk and improve access to financing for small operators. This could be operationalised through state-facilitated lending ecosystems such as a credit facility network of NBFCs with access to blended finance or partial credit guarantees.

Electric Four-Wheelers (Commercial): Bridging the Subsidy Gap

E4WC vehicle sales surged from 541 units in 2019 to 27,995 units per year in 2023, led by the central government's purchase subsidies and supply-side measures such as PLIs, combined with state support. However, the adoption rate stood at a modest 0.63% by 2023 in this segment. To increase E4WC sales and the adoption rate, we recommend the following interventions:

- **Reinstate Support for E4WC:**
  FAME-II's 18% subsidy intensity drove a sharp rise in E4WC sales, unlike the negligible impact seen under FAME-I (~1%). Our analysis shows strong uptake sensitivity to subsidy levels in this segment. With E4WCs now excluded from PM E-DRIVE, this progress risks stalling. Reinstating a minimum central subsidy for commercial EVs can unlock high-impact adoption, support fleet electrification, and sustain momentum in a segment critical for emissions reduction. A short-term minimum subsidy threshold, aligned with segment economics, would be a cost-effective lever to continue rapid adoption in the segment.
- **Supply-side Policy Effectiveness:**
  The strongest positive coefficient observed for auto PLI compared to FAME-II indicates that supply-side interventions might be particularly effective for the E4WC segment. This suggests potential benefits from strengthening manufacturing policies alongside demand incentives and ensuring that the benefits are passed on to consumers.
- **Competition from CNG Alternatives:**
  Commercial vehicles require compelling cost-per-km benefits. Even with subsidies, E4WCs face stiff competition from well-established CNG alternatives not only on TCO basis but also operational ease with a more developed ancillary ecosystem. At present, on an average, the electric versions are priced 40% higher than the CNG version of the same car model. Hence, continued focus on TCO (reduced battery costs, stable electricity prices) is crucial for tipping more fleet operators toward EVs.
- **Post–FAME-II Landscape: Need for Coordinated Support:**
  Beyond reinstating central incentives, sustained progress in the E4WC segment will require clear and coordinated policy signals. The Centre and states should align their efforts through consistent subsidy frameworks, harmonised EV fleet policies, and integrated financing and regulatory support to reduce uncertainty, bridge residual cost gaps, and create an enabling environment for long-term market development.

In summary, while central schemes like FAME-II and the PLI catalysed early growth in E4WC adoption, the absence of electric car subsidies under PM E-DRIVE risks stalling momentum. Surpassing the current 0.63% adoption plateau will require renewed central support, particularly for commercial fleets, alongside coordinated state action. A combined approach, pairing targeted purchase incentives, infrastructure rollout, and manufacturing scale-up can help electric cars compete more effectively with its counterparts in India's commercial vehicle market.

Electric Four-Wheelers (Private): Interventions are essential

Despite gaining momentum in sales since 2020, the adoption rate of E4WP vehicles remains below 2% as of the end of 2024. While subsidies and incentives for E4WP are largely being phased out—except for certain exceptions—at both the central and state levels, achieving a 30% adoption rate in private cars remains an ambitious goal. Prioritizing subsidies for E4WC is a logical approach, given the environmental implications of supporting E4WP growth.

However, the private car market continues to thrive nationwide without substantial government support, making targeted intervention essential for transitioning this segment to cleaner alternatives. To accelerate this shift, we recommend the following actions:

- Reduce the upfront cost of E4WP vehicles and bridge the price gap with ICE vehicles through fiscal measures, such as lower GST rates, waivers or reductions on registration fees, and road tax exemptions.
- Introduce and sustain non-fiscal incentives that enhance the EV ownership experience, including green zones in cities, public parking fee waivers, and reduced toll charges.
- Strengthen charging infrastructure by efficiently distributing incentives to charge point operators, facilitating public charging station development through land allocations, and enabling semi-public and private charging stations via building code modifications.

By implementing these measures, India can accelerate EV adoption and ensure a more sustainable private vehicle market.

Electric Buses: Reimagining Financial and Operational Models

FAME-I and FAME-II laid the essential groundwork, but e-bus targets remain unmet and the purchase incentives seem ineffective. The new PM E-DRIVE scheme (2024–26) continues to allocate significant e-bus subsidies; however, it has reduced to nearly half of what was provided under FAME-II. Both PM E-DRIVE subsidies and the PM-eBus Sewa scheme (payment security mechanism) target the electrification of public buses and do not support the electrification of private buses, which ferry most passengers, especially on inter-city routes.

High upfront costs, lack of leasing models and inadequate charging infrastructure continue to be the main barriers to the electrification of private buses. A few other studies and industry reports have highlighted the challenges and suggested solutions.[47] We suggest that the government take the following initiatives to address these challenges:

- **Include Private Buses in Policy Support**:
  With private operators accounting for majority of India's bus fleet, limiting subsidies to public buses constrains impact. Future schemes should extend support to private inter-city and contract carriage buses through mechanisms like the e-voucher-based incentives or targeted financing.[48] This would align policy with real fleet composition and unlock larger-scale adoption.

[47] Clean Mobility Shift. Electrification of private buses on non-urban routes: the way forward. February 2024; CEEW. The road ahead for private electric buses in India. February 2024.
[48] As introduced under PM E-DRIVE

- **Financial Interventions:**
  Introduce an interest rate subvention scheme to lower the cost of financing by 4-5 percentage points for e-buses. Low-cost, long-term financing would lower the overall cost of e-buses as the financing portion accounts for a large portion of the overall cost, which is also compounded by the fact that e-buses cost 2-3x the price of a diesel bus. The funds needed for this intervention can be mobilised from international development/climate funds.
- **Vehicle Ownership and Operation Models:**
  The government should nudge vehicle financing and leasing companies to offer comprehensive e-bus leasing programmes for private bus operators. This may require state transport authorities to legalise transferable permits in private bus operations. The transport authorities may also allow extra service operation time to compensate for bus charging times.
- **Wayside Amenities:**
  There needs to be robust highway charging infrastructure and parking facilities for inter-city private buses. This will require holistic development of highway amenities, including ample parking and charging equipment, rest areas and convenience/refreshment stores. While the central government has already initiated the development of these facilities, work must be expedited through strong coordination between states and private developers.[49]

[49] MoRTH. Policy Guidelines for Development of Wayside Amenities along NHs and Expressways. Feb 2021.

Conclusion: Policy Pathways, Limitations and Future Direction

India's journey towards electric mobility reveals a nuanced landscape where policy effectiveness varies across vehicle segments and market maturity stages. Our analysis, spanning a decade of data and over 21,000 observations, demonstrates that successful EV policies must evolve beyond subsidising purchases to addressing segment-specific barriers and market realities.

The E2W and E3WP segments have established solid foundations, with FAME-II successfully catalysing the former (showing a multiplier effect of up to 9x) and FAME-I playing a pivotal role in establishing the latter (with a remarkable market multiplier of up to 10x). These segments now require ecosystem support beyond direct subsidies—particularly charging infrastructure, specialised financing and residual value protection. Meanwhile, the E3WC segment demonstrates how well-designed state policies can effectively complement central initiatives, with implementing states reporting 30% higher sales compared to non-implementing states.

Commercial four-wheelers represent a promising frontier, with combined FAME-II and PLI mechanisms driving substantial growth despite competition from CNG alternatives. The e-bus segment, however, highlights that incentives alone cannot overcome structural barriers related to procurement, financing and operational complexity.

As India transitions from FAME schemes to PM E-DRIVE and other similar initiatives, policymakers must recognise that each EV segment requires tailored intervention. Early-stage markets benefit from substantial purchase subsidies while maturing segments need infrastructure and financing support. The remarkable growth across segments from virtually non-existent markets to substantial adoption in just a decade demonstrates that timely and adequate support can accelerate India's electric mobility transition.

Future research should examine two critical relationships regarding charging infrastructure in India's EV transition: first, how fiscal incentives impact the deployment of charging infrastructure; and second, how charging infrastructure availability influences EV sales and adoption rates. We were unable to address either question in our current study, as the available charging infrastructure data was limited to only two years, insufficient for conducting proper empirical assessment of these relationships. Extended datasets capturing both infrastructure development and its correlation with adoption patterns could provide valuable insights for policymakers seeking to optimize the balance between vehicle subsidies and infrastructure investment.

By coordinating central and state measures while progressively shifting focus from subsidies to ecosystem development, India can optimise limited public resources while positioning itself as a global leader in sustainable transportation. The ultimate success of India's EV transition will depend not just on the incentives offered, but also on their strategic calibration to match each segment's unique adoption journey, ensuring long-term market self-sufficiency and sustainable mobility expansion.

Appendix 1: Data and Empirical Methodology

Appendix 1.1 Data and Sample Construction

Our study leverages a 10-year panel dataset (2014-23) with 21,526 monthly observations, covering all major state and central EV policy interventions. In constructing our panel and causal models, we accounted for the dynamic and heterogeneous rollout of state EV policies across India. Our dataset includes all Indian states and union territories and reflects actual market conditions by incorporating key policy transitions such as revocations, expirations, and delayed implementations. For example, Goa's policy was revoked in July 2022 and only reinstated in February 2024. Although a retrospective subsidy mechanism was later announced, this was not known to consumers at the time of purchase. Accordingly, we treated July 2022 as the policy end date to reflect the absence of subsidy signals during the interim. Similar adjustments were made for states like Tamil Nadu, Bihar, and Telangana, where policies expired and were reintroduced outside the study window.

The decision to adopt an extended timeframe stems from two primary considerations. First, it allows us to comprehensively capture the impact of both FAME-I (2015-19) and FAME-II (2019 onwards), alongside PLI and state incentives, ensuring that our analysis accounts for the evolution of India's EV policy landscape. We also account for mid-programme adjustments that were made during the study period (e.g. E2W subsidy under FAME-II). Second, a longer time horizon is crucial to incorporating sufficient variation in SI, a key independent variable in our econometric models. This extended time series significantly enhances the statistical power of our analysis, enabling more robust identification of causal relationships between policy interventions and market outcomes.

Vehicle Segment Classification

We disaggregate our analysis by five distinct EV segments to capture the impact of policy interventions across vehicle types, as detailed in Appendix Table 1.

Table 2: Classification of vehicle class/category

EV Segment	Constituent
Electric Two-Wheelers (E2W)	Two-Wheeler (Transport and Non-Transport)
Electric Three-Wheeler Passenger (E3WP)	E-rickshaw (P) and Three-Wheeler (P)
Electric Three-Wheeler Cargo (E3WC)	E-rickshaw (Goods) and Three-Wheeler (Goods)
Electric Four-Wheelers (E4W)	Split into Commercial and Non-Commercial based on Motor Cab (E4WC) and Motor Car classification (E4WP)
Electric Buses (E-bus)	Bus

These five segments represent the primary vehicle categories eligible for purchase subsidies under India's EV incentive programmes. We excluded other vehicle types such as medium and heavy-duty vehicles, trucks and specialised vehicles, as these were not covered under the central and state purchase subsidy schemes during our study period. Additionally, an exploratory examination of sales data for these excluded segments revealed limited market activity, with insufficient observations to conduct statistically meaningful analysis.

This segment-specific approach allows for granular analysis of policy effectiveness, a departure from studies that treat EVs as a homogeneous category, and acknowledges India's diverse vehicle ecosystem where two-wheelers and three-wheelers constitute major transportation modes.

Appendix 1.1.1 Subsidy Intensity: Constructing the Key Variable

A significant limitation in prior EV policy research (e.g., Sierzchula et al, 2014; Li et al, 2017) has been the reliance on binary treatment variables that simply indicate the presence or absence of subsidies without capturing their magnitude or relative impact. [50,51] This approach fails to account for how varying subsidy levels might differentially influence adoption rates. For example, Mersky et al (2016) noted that Norway's nationally uniform incentives offered no regional variation to exploit, while Münzel et al (2019) found that most analyses focused on markets with significantly different incentive structures across regions. [52,53]

To address this limitation, we developed the "Subsidy Intensity" (SI) metric—a dynamic measure that quantifies the percentage of an EV's per-kilowatt-hour price offset by government subsidies. SI quantifies the actual percentage of an EV's per-kWh price that is offset by government support, calculated as:

$$Subsidy\ Intensity, SI\ = \frac{Subsidy\ per\ kWh}{Average\ Price\ per\ kWh\ of\ EV}$$

This approach offers several analytical advantages:

- **Standardised Comparison:** By expressing subsidies in per-kWh terms, we create a standardised measure across vehicles with different battery capacities and price points.
- **Dynamic Effectiveness Tracking:** SI captures changes in relative policy impact over time, even when absolute subsidy amounts remain constant. For instance, if the per-kWh subsidy remains fixed at Rs15,000 but manufacturers reduce vehicle prices (from Rs60,000/kWh to

[50] Energy Policy. The influence of financial incentives and other socio-economic factors on electric vehicle adoption. Sierzchula W., Bakker S., Maat K., and Van Wee B. 2014.
[51] The market for electric vehicles: indirect network effects and policy design. 2017. Li S., Tong L., Xing J., and Zhou Y. Journal of the Association of Environmental and Resource Economists, 4(1), 89–133.
[52] Transportation Research Part D: Transport and Environment. Effectiveness of incentives on electric vehicle adoption in Norway. Mersky A. C., Sprei F., Samaras C., and Qian Z. S. 2016.
[53] Energy Economics. How large is the effect of financial incentives on electric vehicle sales? – A global review and European analysis. Münzel C., Plötz P., Sprei F., and Gnann T. 2019.

Rs45,000/kWh), the SI would automatically increase from 25% to 33%, reflecting enhanced purchasing power.

- **Economic relevance:** This measurement aligns with consumer decision-making, as it represents the effective price reduction from the buyer's perspective. For example, under FAME-II, a Rs15,000 per kWh subsidy on an E2W with a 2kWh battery (total subsidy: Rs30,000) priced at Rs1,20,000 would yield a 25% SI—a more intuitive measure of incentive strength than the absolute subsidy amount.

The average prices of vehicle models launched in a particular quarter were used to represent the segment's average price per kWh for that quarter, ensuring that the subsidy-to-price ratio accurately reflects market conditions at the time. To calculate this per kWh metric, we collected both the price and battery capacity (kWh) details of the vehicles, using sources detailed in Appendix Table 2. In addition, we computed the subsidy applicable to each vehicle segment under different policy schemes. Some schemes specify subsidies in per-kWh terms, requiring no further transformation. However, some policies define subsidies on a per-vehicle basis. In such cases, we derived per-kWh values by dividing the stated per-vehicle subsidy by the average battery size of that segment within the corresponding quarter.

Our initial observations of varying adoption rates across states with similar policies suggested that relative subsidy strength could be a determining factor in market outcomes. This aligns with findings from Gallagher & Muehlegger (2011), who demonstrated that subsidy effectiveness depends on relative price differentials, not just absolute values. [54]

Descriptive Analysis of SI Patterns and Adoption Trends

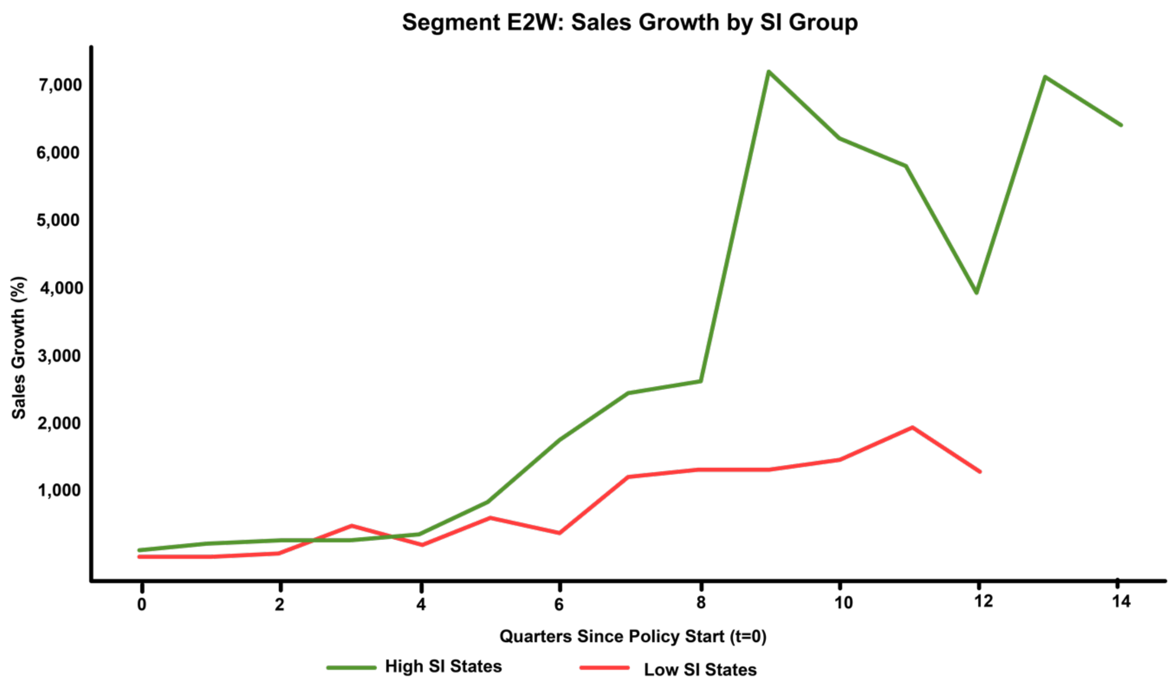
Before conducting formal regression analysis, we examined data trends to gain initial insights into how SIs from both central and state programs affects electric vehicle adoption patterns over time. To explore the relationship between state level SI and E2W sales, we compared post-policy sales growth among states grouped by state SI levels. States were classified into High-SI (top 25% by average SI) and Low-SI (bottom 25%) categories, focusing only on those states with active purchase subsidies during the policy period. Sales growth was measured from a common baseline—the first full quarter after policy implementation (t=0). Growth trajectories were synchronised across states by aligning data to "quarters since policy start" and averaged within each SI group to minimise state-level noise. This approach, while intentionally simple, isolates broad patterns between subsidy levels and adoption momentum, providing a directional check before our more rigorous causal analysis.

This preliminary analysis helped us visualize potential relationships between changing subsidy levels and market responses. Figure 10 shows the trend for an early adopter segment i.e. E2W and suggests that differential SI likely plays a role in pushing adoption as identified in different geographies in prior studies. While the visual correlation between SI variation and adoption patterns

[54] Journal of Environmental Economics and Management. Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology. Gallagher K. S. and Muehlegger E. 2011.

provides preliminary support for our hypothesis that the relative strength of subsidies plays a meaningful role in market development, its role is further validated through econometric methods in the report, which rigorously test the relationship between SI and adoption trends.

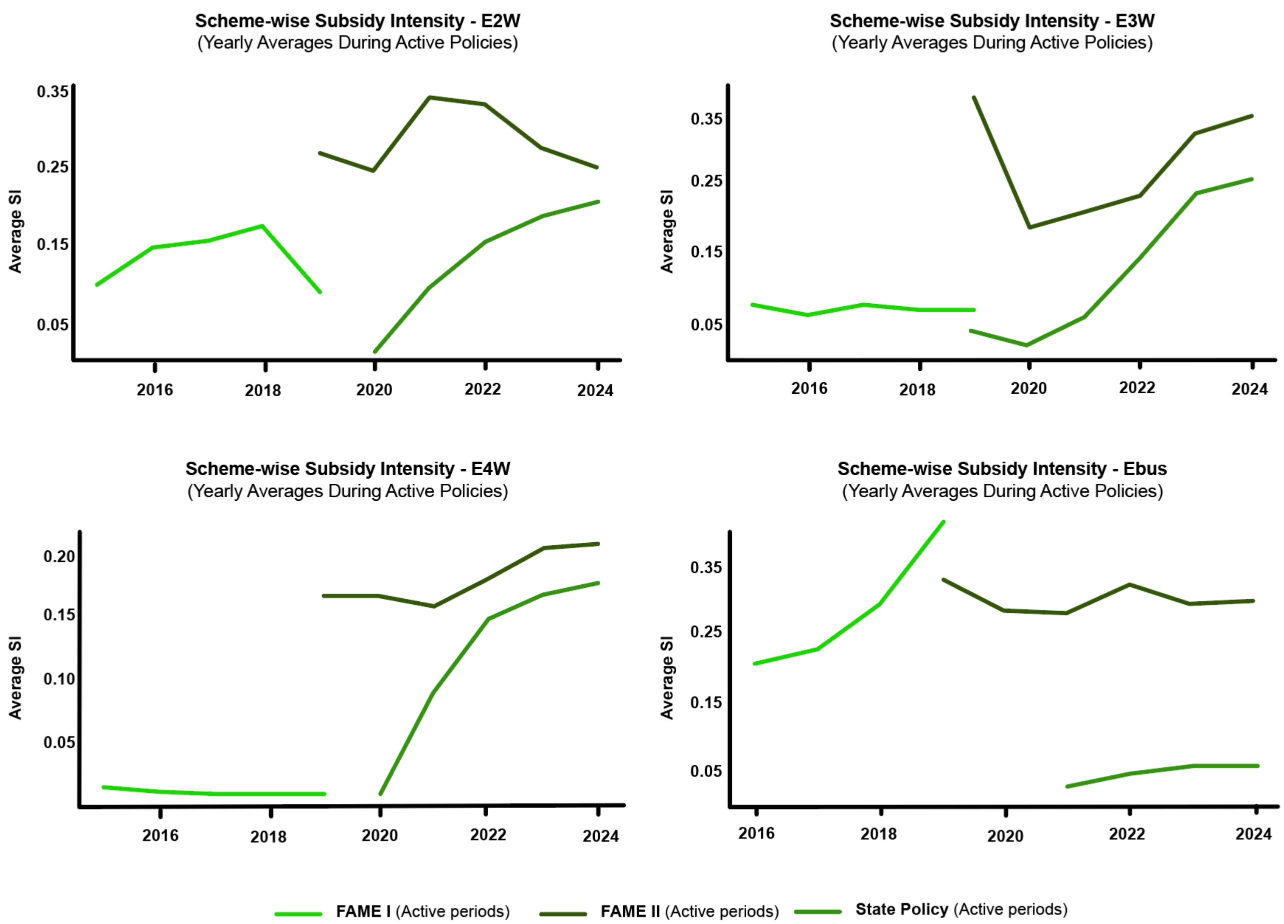
Figure 8: E2W sales growth across High State Level SI and Low State Level SI states



Source: IEEFA Analysis

Further, Figure 11 illustrates the temporal variation in SI for central policies, differentiating between FAME-I and FAME-II, and for state purchase subsidies over their active periods. In many segments, FAME-II consistently shows a higher average SI compared to FAME-I, suggesting an increase in subsidy amounts (while also being affected by a change in vehicle pricing that elevates the subsidy's relative share). For most segments, except e-buses, state-level SI increases over time, indicating that states are progressively enhancing fiscal support. In contrast, the e-bus segment shows high central SI with relatively low state contributions. These nuances provide a logical framework for understanding the evolving landscape of financial incentives, which is further analysed in our econometric assessments.

Figure 9: Average SI across Central Policies



Source: IEEFA Analysis

Appendix 1.1.2 Treatment of Production-Linked Incentive Scheme

For supply-side interventions like PLI, which do not specify vehicle-level subsidies, we adopted a proportional allocation approach. We distributed the total budget allocated for PLI for auto components and ACC battery by scaling the amount based on the number of vehicles sold in each EV category after the PLI schemes were introduced. This methodology provides a realistic approximation of how benefits would flow across segments based on their market sizes.

By proportioning the total budget in this manner, we were able to derive a standardised Rs/vehicle measure for PLI benefits. This conversion allowed us to calculate a PLI SI metric consistent with the purchase SI variables used elsewhere in our analysis. This consistency enables direct comparison of PLI effectiveness against other policy instruments within the same analytical framework, strengthening the robustness of our cross-policy conclusions.

While the ACC battery-linked PLI was not fully disbursed during the period of the sample considered in the study, we have assumed that OEMs have planned their capital expenditure investments based on the policy signal that they will eventually receive the battery PLI funding. This assumption reflects industry behaviour, where manufacturing decisions often anticipate announced policy benefits before actual disbursements occur.

The SI for the ACC Battery PLI has a minimal contribution to our constructed PLI variable, primarily due to no subsidy disbursals resulting from pending compliance by bid winners who have yet to meet key eligibility requirements. The observed effects are largely driven by the PLI for the automobile and auto component industry, which means the findings reflect the impact of incentives on vehicle manufacturing rather than battery production.

Appendix 1.1.3 Additional Variables and Data Sources

Other key variables include adoption rate, relative operating costs and demographic variables, among others, which is shown in Appendix Table 2.

Table 3: Variable Definitions, Descriptions and Data Sources

Variable	Description	Source
Registration (Reg)	Monthly EV registrations for each segment. Primary metric for adoption. We also constructed a Reg per capita variable for our models.	Vahan Dashboard (Vehicle Registration)
Adoption Rate (AR)	$AR = \frac{EV\ Registrations\ (Segment)}{Total\ Registrations\ \ (Segment)}$ Measures EV share within each vehicle segment. Total Registrations includes all fuel types of that segment.	Vahan Dashboard (Total EV Registrations by Segment)
Subsidy Intensity (SI)	$SI\ = \frac{Subsidy\ per\ kWh}{Average\ Price\ per\ kWh\ of\ EV}$	Authors’ calculations using vehicle level subsidies (in per kWh) under each scheme published in government documents. Price data were sourced from the JMK Research database,

		OEM websites, news reports, and reputable third-party automobile sources, while battery specifications were obtained from the MHI website, OEM specifications, and verified third-party platforms.
Demographic Data	This includes annual projected population (Component Cohort Method) by state (2014-24); state-wise per capita income derived from annual NSDP; state-wise mean age (years) was calculated using Census projections, national mean substituted where unavailable. State-wise literacy rate (%) for population aged 15+	National Commission on Population (MoHFW), State Economic Surveys, RBI, PLFS, NSSO surveys.
Relative Operating Cost (Rel_OC)	Rel_OC measures the per-kilometre cost of operating an EV compared to an ICE or CNG vehicle within the same segment. This variable was constructed using state-wise electricity tariffs, fuel prices, and segment-specific mileage data. $EV\_OC = \frac{\text{Electricity Tariff (INR/kWh)}}{\text{EV Mileage (km/kWh)}}$ $ICE\_OC = \frac{\text{Fuel Price (INR/litre)}}{\text{ICE Mileage (km/litre)}}$ $Rel\_OC = \frac{EV\_OC}{ICE\_OC}$	BEE TCO Calculator and MHI FAME website for vehicle specifications and benchmarking mileage data; Central Electricity Authority (CEA) Reports and State Tariff Orders for EV Tariff; Web sources with historical data for fuel prices

Appendix 1.2 Empirical Methods

India's EV policy landscape features a two-tier incentive system: FAME-I, FAME-II and the PLI schemes form the core of central support in terms of fiscal incentives, while many states offer additional purchase subsidies. Because these central and state measures are typically additive, they create considerable variations in total support across states, segments and time. This variation offers a unique natural laboratory: we can track how higher or lower SI affects monthly EV sales and EV market shares (adoption rates), controlling for an array of contextual variables.

At the same time, this approach poses an analytical challenge. When a state purchase subsidy coincides with FAME-II or PLI, disentangling each policy's marginal impact can be tricky. We, therefore, adopt two main strategies:

- A panel regression to gauge the effect of central incentives, focusing on how higher or lower SIs for FAME or PLI translate to shifts in EV uptake.
- DiD and SCM to assess state-level subsidies. Because many states introduced their own incentives after FAME-II had already been launched, we effectively have a "before-after" window for each state policy. This allows for a causal interpretation: does a post-policy jump in EV sales (or share) truly reflect a state subsidy effect above and beyond central subsidies?

While panel regression with fixed effects has been widely applied to the US and European EV markets (Clinton & Steinberg, (2019)), such methods have not been systematically employed for India earlier. Our study is, as far as we know, the first to apply a fixed-effects panel regression with a continuous measure of SI across multiple EV categories to assess policy effectiveness in India.

In principle, one might consider a DiD design for the causal impact of central policies as well. However, for central policies, we do not have a clean "pre-FAME" baseline across all states as FAME-I was launched in 2015, and EV data before that are too sparse for a meaningful analysis. Therefore, a panel regression is our principal method to measure how central incentives correlate with EV outcomes over time. In contrast, for state subsidies introduced after FAME-II, we can exploit a DiD approach, because states that adopt these new incentives have a pre-policy window to compare with.

Appendix 1.2.1 Panel Regression for Impact of Central Policies

Given the longitudinal nature of our dataset, we employ a panel regression framework with fixed effects, which offers several advantages. State fixed effects control for time-invariant regional characteristics such as infrastructure and consumer preferences, while time fixed effects account for common macroeconomic shocks. This approach, widely used in US and European studies on EV adoption (Clinton & Steinberg, (2019); Münzel et al, (2019)), effectively addresses unobserved heterogeneity across regions. However, its application in the Indian EV context has been limited—a gap our study aims to fill.

We constructed a monthly panel dataset to examine the effectiveness of national programs (FAME-I, FAME-II, PLI), where each observation represents a specific combination of state, vehicle segment, and month. For example, our dataset includes observations such as "Delhi, electric two-wheelers, April 2021" and "Maharashtra, electric three-wheelers, May 2022." This structure enables us to track how EV adoption in each segment within each state responds to changes in subsidy intensity over time.

We construct a monthly panel indexed by (*s,e,t*), where '*s*' is a state or a union territory, '*e*' an EV segment (e.g., electric two-wheelers, three-wheelers, four-wheelers, etc.), and '*t*' denotes the date of observation which are recorded monthly. We then observe EV outcomes and controls using a one-month lead in the dependent variable.[55] Hence, if the sales or adoption rate is measured in month *t*+1, our main regressors (including SI) use information at month *t* as represented in the below regression equation:

$$ln\ (Y_{s,e,t+1}) = \alpha + \beta SI_{e,t} + \gamma ln(RelOC_{s,e,t}) + \delta X_{s,t} + \mu_s + \theta_t + \varepsilon_{s,e,t} \qquad (1)$$

We use two dependent variables ($Y_{s,e,t+1}$) separately in regressions: a) Monthly Registrations/sales - The natural logarithm of monthly EV registrations; b) Adoption Rate (AR): The adoption rate, computed as the ratio of EV sales to comparable ICE sales in that segment and month which indicates whether EVs gain market share.

- **Monthly Registrations/Sales:** This absolute measure captures the raw volume of EVs sold in each state and segment, providing insight into market growth in absolute terms. It helps quantify how policies affect EV uptake and is useful for understanding the scale of market expansion.
- **Adoption Rate:** Calculated as the ratio of EV sales to total vehicle sales (including ICE and CNG vehicles) within the same segment and month. This relative measure reveals whether EVs are gaining market share against conventional alternatives, providing a clearer picture of the market transformation process. A policy might successfully increase absolute EV sales while failing to significantly alter the overall market composition if conventional vehicle sales also grow proportionally.

Using both metrics provides complementary perspectives on policy effectiveness. While registration numbers demonstrate a policy's ability to stimulate immediate sales growth, adoption rates reveal whether that policy is driving deeper market transformation. This dual approach helps explain cases where policies generate impressive sales but achieve only modest progress in transitioning the overall vehicle fleet away from fossil fuels.

The key independent variable is the subsidy intensity ($SI_{e,t}$) of central purchase subsidies, calculated as the per-kWh subsidy for a particular EV segment divided by the average per-kWh price of newly introduced EV models. Higher SI implies that a larger fraction of the EV price is offset by the government subsidy, so we expect higher EV sales. We also account for the relative operating cost ($\ln\ (RelOC_{s,e,t})$) of running an EV vis-à-vis an ICE vehicle in the same segment. It is the ratio of electricity cost for an EV and fuel (diesel/petrol/CNG) in Rs/km. This variable helps understand how day-to-day energy expenses might drive EV sales or adoption rates. We also account for any

[55] We include a one-month lead in the dependent variable to help mitigate endogeneity concerns, particularly reverse causality. If a sudden surge in EV registrations were to influence the timing or magnitude of a subsidy, measuring both in the same month could affect our estimates. By shifting registrations or adoption rates to the following month, we reduce the likelihood that policy decisions are driven by the very outcomes we aim to explain. While this one-month lead does not wholly eliminate endogeneity, it provides a practical buffer, ensuring that observed policy variables precede the corresponding registrations.

potentially time-varying, state attributes with a set of macro-economic and demographic controls $X_{s,t}$, including:

- Per-capita income of the state, capturing consumers' ability to afford novel, potentially pricier technologies.
- Literacy and mean age in the state, acknowledging that the adoption of new technologies can hinge on educational and demographic profiles.

Our model incorporates fixed effects at two levels. We control for unobserved, time-invariant, state characteristics through the use of state-level fixed effects (μ_s). To control for national trends or macro-economic factors, we use year fixed effects (θ_t). Finally, we use standard errors, which are clustered at the state-level to address the possibility of within-group correlation in regressors and error terms.

Appendix 1.2.2 Difference-in-Differences and Synthetic Control for State Policies

When it comes to state incentives, we have a more natural "before-after" contrasting data because many states introduced EV schemes after FAME-II. That means we do observe a genuine pre-policy period in which a state did not have its own incentive, even though it might have been influenced by national policies. Another state that never implemented a subsidy (or did so later) can serve as a control. This methodological approach allows us to move beyond establishing association using panel regression to establish causality in policy effectiveness.

This setup allows a DiD design, which is well-suited for evaluating causality: if a "treated" state sees a disproportionate jump in EV outcomes right after implementing its purchase subsidy (while no similar jump occurs among control states), this strongly suggests a true policy effect, rather than mere correlation or national trends.

Formally, we let $Treat_s$ denote a binary indicator for whether state s ever enacts a subsidy during our study period (1 for treated states, 0 for control states), and $Post_{s,t}$ indicate whether time period t is after state s's subsidy has been implemented (1 for post-subsidy periods, 0 for pre-subsidy periods).. The DiD coefficient on $Treat_s \times Post_{s,t}$ captures the incremental impact, i.e. how much more (or less) EV adoption or sales jumped because of the state subsidy. The DiD specification controls for the same socio-economic variables discussed in equation (1).

Because states adopting subsidies may differ fundamentally from those that do not, we implement propensity score matching (PSM) before running the DiD regression. PSM pairs each "treated" state with one or more "untreated" states that were similar on key pre-policy indicators (state per capita income, literacy level and mean age), so that differences in EV uptake post-policy are more plausibly attributable to the new state incentive, rather than underlying disparities in specific state characteristics.

We then estimate, for an outcome $(Y_{s,e,t+1})$ i.e. sales or adoption rate (similar to the one used in equation (1)) using the following DiD specification:

$$ln(Y_{s,e,t+1}) = \alpha + \beta\ (Treat_s\ \times Post_{s,t}) + \gamma ln(RelOC_{s,e,t}) + \eta TotalCSI_{e,t} + \delta X_{s,t} + +\mu_s + \theta_t + \varepsilon_{s,e,t} \quad (2)$$

The coefficient β on the interaction term indicates whether the new state subsidy meaningfully boosts EV sales or adoption rate relative to states that never adopt or adopt later. To disentangle overlapping central policies, we also include an aggregate measure of TotalCSI. The rest of the variables and parameters in equation (2) are similar to the ones used in equation (1).

Synthetic control method for additional robustness

Beyond the DiD approach, we employ a counterfactual reconstruction methodology to assess the complementary effect of state EV subsidy policies. This approach builds on the SCM but is framed more broadly to generate a plausible estimate of how EV adoption would have progressed in a state had the policy not been introduced and thus answers the "what if" question. By systematically constructing a counterfactual state, one that closely mirrors[56] the pre-policy characteristics of the treated state, we create a rigorous baseline against which the policy's impact can be measured.

To ensure the validity of this counterfactual reconstruction, we match states based on multiple pre-treatment outcome lags (EV sales 12, six and three months before intervention), economic indicators (state per capita income), market-specific variables (fuel prices) and demographic characteristics (literacy levels, mean age etc). By weighting control states optimally rather than selecting a single untreated counterpart, this method minimises bias arising from idiosyncratic state-level differences and external market shocks.

A key feature of this analysis is the careful selection of the donor pool (which constructs the counterfactual scenario), ensuring that states that implemented EV policies within 24 months of the treated state's policy adoption are excluded. This prevents contamination effects and ensures that the reconstructed counterfactual reflects market conditions unaffected by similar policy changes.[57] The Average Treatment Effect (ATE)[58] is then computed as the mean monthly difference between observed EV sales in the treated state and its counterfactual estimate. Any significant positive deviation post-policy suggests that state incentives accelerated EV adoption beyond what would have been expected under central schemes alone.

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[56] We validate the robustness of our matching process using statistical measures such as Root Mean Squared Prediction Error (RMSPE) and in-time placebo tests to ensure accuracy.

[57] Though we have conducted the counterfactual reconstruction for multiple states, in this report, we present only the first mover states that implemented a purchase subsidy. We will share other states' analysis upon request.

[58] $ATE = \frac{1}{T}\sum_{t=1}^{T}(Y_t^{treated} - Y_t^{synthetic})$; $Y_t^{treated}$ is the observed number of EV registrations in the treated state at time t; $Y_t^{synthetic}$ is the number of EV registrations for the synthetic control at time t, summation taken over post-treatment time period.

Appendix 1.3: Key Assumptions

Our study is based on several key assumptions that ensure the robustness and interpretability of the results while acknowledging potential limitations in data availability, policy implementation and market behaviour.

Pricing Data

- For pricing data, where no new EV models are launched in a given quarter, we extend the previous quarter's average prices, recognising that older models continue to be available for sale in subsequent periods.
- Subsidy benefits are reasonably passed on to consumers.

Vehicle Battery Chemistry and Vehicle Segments

- Since Vahan data does not specify battery chemistry and categorises vehicles under 'electric' fuel type, we assume that registrations in the E3W segment may include both lithium-ion and lead-acid battery vehicles.
- We restrict our analysis to E4WCs across both phases. This choice reflects data ambiguities in the broader E4W category, which may include premium electric cars not eligible under FAME schemes. Since such vehicles are typically used for personal rather than commercial purposes, focusing on commercial E4Ws helps avoid this contamination and allows for a more accurate assessment of policy-linked uptake.

Vehicle Registration as Adoption Indicator and Policy Implementation

- While vehicle registration figures generally provide a reliable measure of adoption, certain segments—particularly E2Ws and E3Ws—may exhibit minor discrepancies due to:
- Variations in reporting standards
- Delays in registration
- Market-specific factors such as informal sales channels
- Despite these potential inconsistencies, the overall registration trends accurately reflect market adoption patterns across states.
- For central policies, we assume uniform application across states, ensuring consistency in subsidy availability, policy impact evaluation and market response.

Territorial & Administrative Data Consistency

- The administrative restructuring of UTs does not significantly impact long-term EV adoption trends.
- For consistency in state-level comparisons, UTs that have undergone administrative changes (e.g., Daman & Diu and Dadra & Nagar Haveli, as well as Jammu & Kashmir) are retrospectively merged in our analysis.
- This approach ensures that policy impacts and adoption trends remain aligned across the study periods.

Appendix 2: Economic Significance and Market Multiplier: Methodology and Calculations

Economic Significance vs. Statistical Significance

While statistical significance (p-values in regression models) confirms that observed relationships aren't due to random chance, economic significance quantifies the real-world magnitude of policy impacts. This allows policymakers to evaluate whether statistically significant effects translate into meaningful market outcomes that justify program expenditures.

Market Multiplier: A Key Policy Efficiency Metric

The market multiplier measures how many total vehicles were sold in the market for each vehicle directly attributable to a policy intervention. This reveals the full market impact beyond just direct subsidy effects—showing how government support catalyzed broader market forces.

These multipliers should be interpreted as upper bound estimates, as they may attribute market growth to policies that could partially result from unobserved factors. They assume uniform policy impact across regions and demographics, consistent subsidy-to-sales relationships, and rely on statistical models with inherent uncertainty.

These comparative multipliers help policymakers identify which segments deliver the highest return on fiscal investment, potentially allowing reallocation of resources from high-multiplier segments to other areas requiring support as markets mature.

Methodology for Market Multiplier Calculations

To quantify the policy impact in concrete terms and derive market multipliers, we apply a systematic approach that translates statistical results into economically meaningful metrics. The following calculations demonstrate how we determine the volume of vehicles directly attributable to policy intervention.

E2W

- The analysis employs SI data from separate policy phases:

FAME-I (2015 to March 2019) at 14.32% intensity.
FAME-II (April 2019 to 2023) at 28.65% intensity.

- The regression on ln(Reg) shows:

A coefficient of 2.224 for FAME-II’s SI.

A standard deviation of 0.0539 for the FAME-II SI variable.
Hence, the one-SD increase in FAME-II SI → 2.224 × 0.0539 = 0.1198.
Exponentiating 0.1198 yields exp (0.1198) ≈ 1.127, or +12.7%.

For each year from 2019 through 2023, the "counterfactual E2W volume" is calculated by dividing the actual E2W sales by 1.127.

Table 4: E2W Vehicle Registrations

Year	Actual Registrations	Counterfactual Registrations (actual ÷ 1.127)	Policy-Driven Registrations
2019 (since FAME-II i.e. April 2019)	19,333	17,149	2,184
2020	31,381	27,836	3,545
2021	173,378	153,792	19,586
2022	557,179	494,236	62,943
2023	659,397	584,907	74,490
Total	1,440,668	1,277,920	162,748

Average market multiplier during FAME-I = 1,440,668÷162,748 = 8.86x

- Translating the sales impact into monetary values: The average E2W price Rs108,196 is estimated by multiplying an average battery capacity of 2.56 kWh by an average cost of Rs42,264 per kWh (figures drawn from the analysis of quarterly model launches during FAME-II). Multiplying the "policy-driven" volumes by this price indicates the direct monetary value attributable to the one-SD increase in FAME-II SI:

Direct policy value: Rs176.09 billion represents the economic value directly attributable to FAME-II SI.
Total market value: Rs1,558.79 billion represents the entire E2W market value during this period.

This demonstrates exceptional policy leverage, where each rupee of policy-driven value catalysed nearly nine rupees of total market creation.

E3WP

1. FAME-I Calculation (2015-19)
    - The ln(Reg) regression yields a coefficient of ~10.578 on FAME-I_SI, and the standard deviation of FAME-I_SI is ~0.0101.
    - One-SD change in FAME-I_SI → 10.578 × 0.0101 = 0.1070 → exp(0.1070) ≈ 1.112, or +11.2% in monthly registrations.

- For each year's actual E3WP sales, we divide by 1.112 to obtain a counterfactual. The difference is considered 'policy-driven' registration.

Table 5: E3WP Vehicle Registrations

Appendix Table 3.2			
Year	Actual Registrations	Counterfactual Registrations (actual ÷ 1.112)	Policy-Driven Registrations
2015	5,422	4,873	549
2016	47,175	42,395	4,780
2017	81,971	73,665	8,306
2018	104,665	94,059	10,606
Till March 2019	27,229	24,470	2,759
Total	266,462	4,050.22	27,000

Average market multiplier during FAME-I period = 266,242÷27,000 = 9.87x

E4WC

- Policy Impact Calculations:
    - FAME-II coefficient: 2.397
    - Standard deviation of FAME-II intensity: 0.02
    - Impact calculation: exp (2.397 × 0.02) = 1.051 or 5.1% increase
- For each year's actual E4WC sales, we divide by 1.051 to obtain a counterfactual. The difference is considered 'policy-driven' registration.

Table 6: E4WC Vehicle Registrations

Appendix Table 3.2			
Year	Actual Registrations	Counterfactual Registrations (actual ÷ 1.051)	Policy-Driven Registrations
2019 (since FAME-II i.e. April 2019)	757	721	36
2020	2,029	1,931	98
2021	6,450	6,138	312
2022	18,585	17,686	899
2023	39,993	38,057	1,936
Total	67,815	64,533	3,282

Average market multiplier during FAME-II period: 67,815÷3,282 = 20.66x

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The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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