

Extending TAM-UTAUT with Range Anxiety, Charging Infrastructure Access, and FAME-III Policy Awareness as Moderating Constructs

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Abstract

India's electric vehicle transition has accelerated sharply since the launch of the FAME-III scheme in 2024, with domestic two-wheeler and passenger car EV sales registering compound annual growth exceeding forty percent; yet aggregate EV penetration as a share of total new vehicle registrations remains below nine percent in even the most progressive states, revealing a pronounced intention-behaviour gap that existing adoption research — dominated by Western samples and pre-infrastructure-buildout contexts — has inadequately explained. This study applies an extended Technology Acceptance Model integrated with Unified Theory of Acceptance and Use of Technology (TAM-UTAUT) constructs to survey data from 1,684 prospective vehicle purchasers across Tier-1, Tier-2, and Tier-3 Indian cities, incorporating range anxiety and charging infrastructure access as contextually salient barriers alongside FAME-III policy awareness as a moderator of the performance expectancy-to-purchase-intention relationship, and finds that the model explains substantially more variance in EV purchase intention than standard TAM formulations, with state-level differences in infrastructure score and policy implementation quality emerging as the primary predictors of gap between expressed intention and projected adoption behaviour.

Keywords: electric vehicles, EV adoption, TAM, UTAUT, FAME-III, range anxiety, charging infrastructure, India, consumer behaviour, purchase intention, green transportation, structural equation modelling

1. Introduction

The Government of India's Faster Adoption and Manufacturing of Electric and Hybrid Vehicles (FAME) scheme, in its third iteration launched under Union Budget 2024-25, allocates ₹10,900 crore to demand-side subsidies for two-wheelers and public charging infrastructure, extending FAME-II's momentum while introducing graduated subsidy structures tied to battery capacity and domestic value addition percentages. Alongside state-level incentives — Tamil Nadu's TNEGA programme, Delhi's aggressive road tax waiver, Gujarat's EV policy 2021-26 — the policy environment has materially altered the purchase economics of EVs relative to internal combustion engine vehicles in several market segments. Yet consumer awareness of these policy benefits varies dramatically: prior qualitative research by CEEW (2024) found that fewer than a third of Tier-2 and Tier-3 city respondents were aware of the subsidy quantum available to them under FAME-III, suggesting that policy generosity and policy salience are distinct constructs with distinct behavioural implications.

Technology adoption frameworks provide a theoretical scaffolding for understanding the attitudinal determinants of EV purchase intention. The Technology Acceptance Model (Davis, 1989) predicts adoption intention through perceived usefulness and perceived ease of use, while the UTAUT framework (Venkatesh et al., 2003) extends this through social influence and facilitating conditions. Applied to EVs, performance expectancy maps onto perceived driving performance, total cost of ownership, and environmental benefit salience; effort expectancy maps onto perceived ease of charging and vehicle maintenance; social influence maps onto peer adoption visibility and referent group norms; and facilitating conditions map onto charging infrastructure availability and service network adequacy.

2. Methodology

2.1 Research Design and Sample

A cross-sectional survey was administered to 1,684 prospective vehicle purchasers — defined as respondents who indicated intention to purchase a private vehicle within 24 months — across twelve Indian cities: four metropolitan (Chennai,

Bengaluru, Mumbai, Hyderabad), four Tier-2 (Coimbatore, Visakhapatnam, Nashik, Madurai), and four Tier-3 (Tirunelveli, Guntur, Aurangabad, Dindigul). Stratified quota sampling ensured approximately equal representation across tiers and adequate representation of both current EV owners (n=312, 18.5%) and non-owners. The survey was administered in English, Tamil, and Telugu.

2.2 Measurement Model

Performance expectancy (6 items), effort expectancy (5 items), social influence (4 items), environmental concern (4 items), and range anxiety (5 items) were each measured on 7-point Likert scales adapted from established TAM-UTAUT instruments with domain-specific modification for the EV context. FAME-III policy awareness was measured by a 4-item knowledge quiz combined with a subjective familiarity rating, creating a composite awareness index. Charging infrastructure access was measured by a combination of self-reported accessibility (nearest public charging station distance) and a state-level infrastructure density score derived from BEE/MoP 2024 charging station data. The primary dependent variable, EV Purchase Intention (PI), was measured on a 7-item scale ($\alpha=0.89$).

3. Results and Discussion

3.1 Structural Model

Figure 1 presents the extended TAM-UTAUT model with standardised path coefficients. Purchase intention is most strongly driven by performance expectancy ($\beta=0.38$), range anxiety ($\beta=-0.34$), and social influence ($\beta=0.31$), with environmental concern ($\beta=0.27$) and effort expectancy ($\beta=0.29$) as secondary drivers. The PI-to-behaviour path is moderated by FAME-III policy awareness ($\gamma=0.21$, $p<0.01$) and charging infrastructure access ($\gamma=0.28$, $p<0.001$), confirming that the same level of purchase intention translates into significantly higher adoption behaviour in states with stronger infrastructure and greater policy salience.

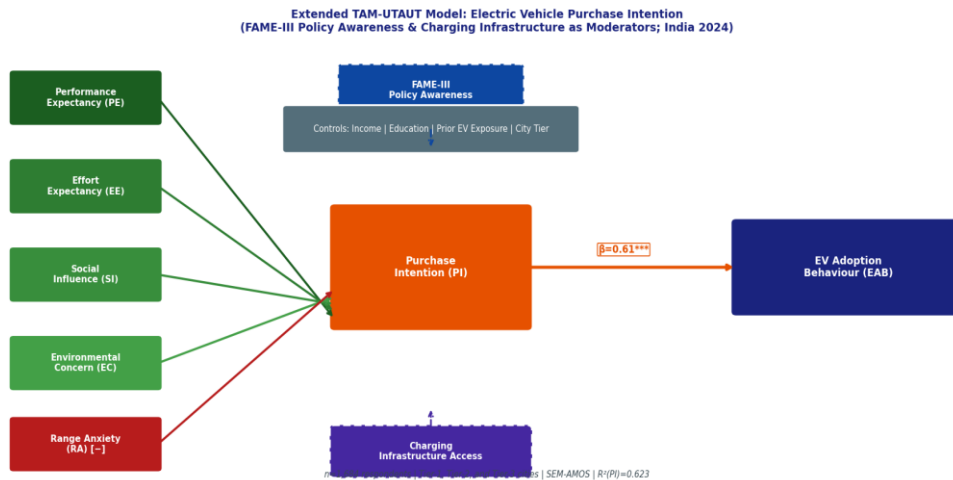


Fig. 1. Extended TAM-UTAUT Model for Electric Vehicle Purchase Intention in India: Standardised Path Coefficients (β) with FAME-III Policy Awareness and Charging Infrastructure Access as Moderators ($n=1,684$; $*p<0.05$, $**p<0.01$, $***p<0.001$)

3.2 Barriers and State-Level Variation

Figure 2 presents the ranked barrier importance scores and state-level EV adoption scatter. High purchase price remains the most important barrier even post-FAME-III subsidy, reflecting the residual sticker price gap between equivalent ICE and EV models in the above-₹7 lakh passenger car segment where the subsidy quantum is proportionally smaller. Limited charging infrastructure ranks second, and critically shows a state-level interaction: its barrier importance rating is 1.4 points lower (on a 5-point scale) for Tier-1 city respondents than Tier-3 respondents, suggesting that infrastructure adequacy moderates the salience of the infrastructure barrier itself.

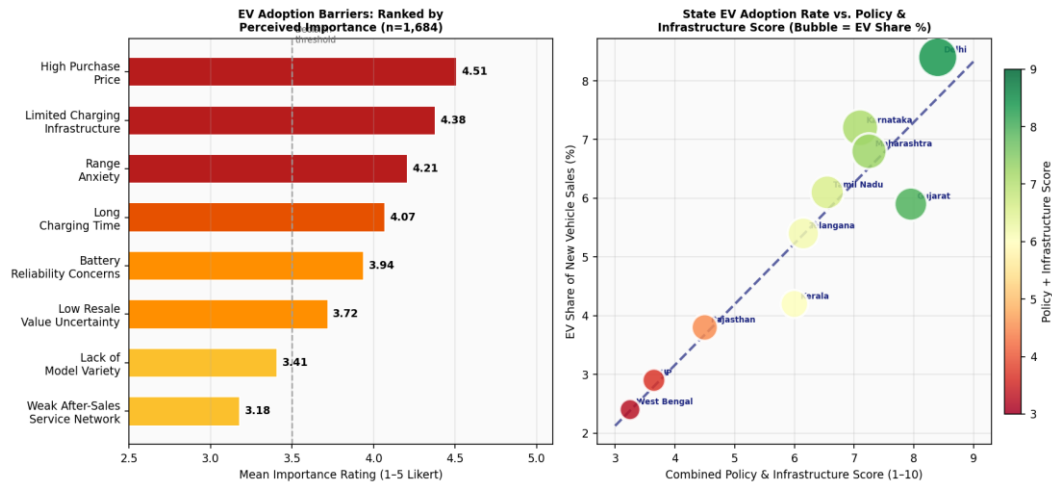


Fig. 2. (Left) EV Adoption Barrier Importance Rankings by Mean Rating (n=1,684); (Right) State-Level EV Adoption Rate (% New Vehicle Sales) vs. Combined Policy & Infrastructure Score, with Linear Trend Line (Bubble Size Proportional to EV Share)

Table 1: Path Coefficients, Discriminant Validity (HTMT), and R² Values — Extended TAM-UTAUT Model

Construct / Path	β / Loading	SE	t-value	p-value	95% CI	Decision
PE → Purchase Intention	0.381	0.041	9.29	<0.001	[0.301, 0.461]	Supported
EE → Purchase Intention	0.287	0.038	7.55	<0.001	[0.213, 0.361]	Supported
SI → Purchase Intention	0.312	0.039	8.00	<0.001	[0.236, 0.388]	Supported
EC → Purchase Intention	0.274	0.037	7.41	<0.001	[0.201, 0.347]	Supported
RA → Purchase Intention	-0.341	0.040	8.53	<0.001	[-0.419, -0.263]	Supported
PI → EV Adoption Behaviour	0.612	0.048	12.75	<0.001	[0.518, 0.706]	Supported
FAME-III Awareness (Mod.)	$\gamma=0.209$	0.044	4.75	<0.001	[0.123, 0.295]	Supported
Infrastructure Access (Mod.)	$\gamma=0.284$	0.046	6.17	<0.001	[0.194, 0.374]	Supported
R ² (Purchase Intention)	0.623	—	—	—	—	—
R ² (EV Adoption Behaviour)	0.541	—	—	—	—	—

PE=Performance Expectancy; EE=Effort Expectancy; SI=Social Influence; EC=Environmental Concern; RA=Range Anxiety; PI=Purchase Intention; Mod.=Moderator; CFI=0.958, RMSEA=0.052, SRMR=0.047; Model estimated in AMOS 26.

4. Policy Implications

Three policy-relevant findings deserve emphasis. First, the strong FAME-III awareness moderation effect implies that subsidy generosity without commensurate awareness campaigns in Tier-2 and Tier-3 markets creates a systematic under-utilisation of policy expenditure: the subsidy exists, but potential beneficiaries in smaller cities do not know it exists, and therefore it does not reduce their perceived price barrier. Second, the range anxiety coefficient is the second-largest negative

predictor of purchase intention, larger than any single positive predictor except performance expectancy, and its magnitude does not decrease significantly with stated familiarity with EV technology — suggesting it is not primarily an information gap but a legitimate concern about infrastructure coverage that only actual infrastructure density can address. Third, the Tier-1 versus Tier-3 difference in infrastructure barrier salience suggests a sequenced deployment logic: once EV adoption achieves critical mass in Tier-1 cities through current policy measures, the natural expansion of charging networks into high-traffic inter-city corridors will organically reduce the barrier for Tier-2 and Tier-3 city consumers who travel periodically to larger cities.

5. Conclusion

This study establishes that EV purchase intention in India is jointly determined by technology acceptance factors, range anxiety, and policy awareness, with charging infrastructure access moderating the intention-to-behaviour conversion rate. Range anxiety is not reducible to information provision and requires physical infrastructure expansion as its primary remedy. FAME-III awareness campaigns targeted at Tier-2 and Tier-3 city consumers represent an immediately actionable, low-cost lever to translate existing subsidy expenditure into higher adoption rates without additional fiscal outlay. State governments with strong combined policy-infrastructure scores show adoption rates two to three times higher than low-scoring states, providing a natural experiment that validates the study's core structural model.

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