

## **AI-inspired business models for India's EV ecosystem using simulation framework**

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### **Abstract**

India's EV transition is supported by policy, environmental concerns, and consumer acceptance. Investment decisions remain difficult due to uncertain charging demand and limited real-world data. The study proposes a simple Excel-based feasibility tool for EV charging stations. It integrates demand forecasting, charger sizing, tariff design, and cost analysis. Three scenarios assess utilization, energy use, revenue, costs, cash flow, and payback. The model helps evaluate operational and financial viability under uncertain conditions. It offers a low-cost, transparent, and flexible planning approach for Indian cities.

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## 1. Introduction

Electric mobility is growing due to environmental, policy, and technological factors, supporting emission reduction and sustainable development [1]. India's EV market is growing, but limited and costly charging infrastructure hinders wider adoption [2]. EV adoption depends on effective charging infrastructure, but high costs, uncertain demand, and stakeholder challenges hinder profitable networks [3]. Traditional planning relies on fixed forecasts, which may not suit the rapidly changing EV sector [4]. Limited charging data makes EV infrastructure planning difficult, requiring scenario-based analytical tools for investment decisions [5]. Simulation modelling supports EV planning through demand, cost, scenario, and financial analysis [6]. Innovative EV business models improve convenience and sustainability but face complex ecosystem challenges [7]. India's diverse mobility, tariffs, and regulations require flexible tools to assess EV business model feasibility [8]. Limited research combines EV business models and simulation [9].

## 2. Literature Review

Electric mobility supports sustainable transport by reducing emissions, fossil-fuel dependence, and promoting innovation [1]. EV adoption depends on cost, incentives, technology, awareness, and charging infrastructure [5]. Government support and local manufacturing boost EV adoption, requiring localized strategies [2]. Charging infrastructure boosts EV adoption by improving convenience, confidence, and reducing range anxiety [3]. EV charging faces high investment costs and low early utilization, limiting profitability and private investment [10]. EV charging requires stakeholder collaboration and integrated planning to address technology, economic, and policy challenges [6], [11]. Big data analytics improve energy forecasting and smart-grid efficiency for sustainable EV charging [12].

Business model innovation enables new EV charging revenues and services [7]. Charging subscriptions and BaaS reduce upfront costs and battery concerns [13]. Dynamic pricing matches charging rates with demand and electricity prices, improving efficiency [14]. EV charging demand is uncertain due to changing adoption, driving patterns, prices, and policies [8]. EV demand uncertainty creates investment risks, highlighting the need for flexible scenario-based planning tools [15]. Simulation modelling supports demand forecasting, optimization, and

cost-benefit analysis [16]. Simulation models assess EV adoption, charging demand, and infrastructure profitability [17]. Key gaps are technology–financial integration, emerging-market focus, and scalable simulation. [18], [19] the model exploits the Eye Aspect Ratio (EAR). Addressing these gaps requires sustainable business models, stakeholder integration, and simulation-based planning [20].

### 3. Research Methodology

This study uses simulation to examine AI-based business models for EV adoption in India under data limitations and market uncertainty [8], [16]. The framework combines innovation diffusion and business model analysis to evaluate AI adoption through scenario-based planning [6]. The study models India's growing EV market through a hypothetical medium-sized urban market with 1,000,000 potential adopters [21]. The study measures cumulative EV adopters over a 10-year simulation period [22]. The study uses the Bass diffusion model to estimate EV adoption based on innovation and imitation effects [23], [24]. The model is specified as:

$$(dN(t)/dt) = p[M - N(t)] + q[(N(t)/M)(M - N(t))]$$

where  $N(t)$  is the number of adopters accumulated until time  $t$ ,  $M$  is the market potential,  $p$  is the coefficient of innovation (external influence) and  $q$  is the coefficient of imitation (internal social influence).

The Bass model suits EV diffusion, capturing network effects, social learning, and infrastructure spillovers [6], [17].

AI improves efficiency, information flow, and coordination by adjusting diffusion parameters [25]. Four scenarios are compared: No AI, AI supply chain, AI charging, and full AI, with AI increasing diffusion coefficients by 20–30% [25], [26].

The diffusion parameters  $p = 0.01$  and  $q = 0.30$  are close to the empirical values obtained in previous EV diffusion studies [6], [21]. The study assumes 10,000 early EV adopters, homogeneous urban behaviour, and sufficient electricity supply, ensuring transparent and reproducible scenario modelling [8]. The study simulates EV adoption over ten years and compares market penetration across scenarios, with sensitivity analysis to ensure robust results [16].

Comparative tables and baseline interpretation highlight the incremental contribution of AI-driven business models.

#### 4. Results & Data Analysis

Descriptive statistics set the key parameters: market potential = 1,000,000 and initial adopters = 10,000. Four scenarios are analyzed, with annual cumulative EV adoption presented in Table 1.

**Table 1**  
**Simulated EV Adoption Over 10 Years (Cumulative Adopters)**

| Year | Base Scenario | AI Supply Chain | AI Charging | Full AI Integration |
|------|---------------|-----------------|-------------|---------------------|
| 0    | 10,000        | 10,000          | 10,000      | 10,000              |
| 1    | 25,034        | 27,324          | 26,836      | 29,497              |
| 2    | 44,871        | 50,105          | 51,011      | 56,967              |
| 3    | 70,731        | 79,645          | 85,054      | 94,861              |
| 4    | 103,913       | 117,267         | 131,710     | 145,638             |
| 5    | 145,638       | 164,096         | 193,325     | 211,097             |
| 6    | 196,791       | 220,749         | 270,828     | 291,398             |
| 7    | 257,585       | 286,978         | 362,563     | 384,119             |
| 8    | 327,231       | 361,363         | 463,636     | 483,987             |
| 9    | 403,734       | 441,249         | 566,576     | 583,806             |
| 10   | 475,898       | 514,870         | 654,153     | 667,632             |

By year 10, full AI yields 667,632 adopters (67% penetration), versus 475,898 (48%) in base.

##### 4.1 Simulation Results:

The simulation results compare the EV adoption in four business model scenarios: (i) without any artificial intelligence (AI) the baseline scenario, (ii) with AI integration in a supply chain optimization, (iii) with AI integration in charging infrastructure management, and (iv) with full AI integration throughout the EV ecosystem. Adoption is calculated as the cumulative number of adopters over 10 years, as done in medium-term infrastructure planning [6]. In all the scenarios, EV diffusion follows the typical S-shaped diffusion curve that is expected by innovation diffusion theory [23], [24]. AI influences EV diffusion beyond productivity gains. Baseline adoption reaches 48%, while AI supply chains reach 51–52%; limited charging remains a key barrier. AI-powered charging reaches 65% market penetration in 10 years [3], [10]. Full AI integration achieves about 67% EV adoption by improving both innovation and imitation effects.

Sensitivity analysis confirms that the simulation results remain robust under plausible parameter variations [16].

## 5. Discussion and Theoretical Contributions

AI-driven business models can accelerate EV adoption through better coordination, transparency, user experience, and trust, with consumer-focused AI charging showing stronger diffusion effects [5], [15]. The study extends diffusion theory by treating AI as an endogenous factor [23]. AI boosts EV diffusion through learning, networks, and perceived value [20]. The study links AI-enabled value creation with EV adoption, showing how AI-driven business models can support economic and environmental sustainability [7]. AI enables scalable, resilient, and sustainable EV systems.

## 6. Conclusion, Limitations and Future Research

**Conclusion:** AI-driven business models can accelerate EV adoption in India, especially through smart charging infrastructure, with full AI integration reaching nearly two-thirds market penetration and supporting sustainable mobility, investment, and infrastructure development.

**Limitations:** The study is limited by simulated data, homogeneous adopters, and the exclusion of competition and spatial effects. AI is also modelled indirectly, suggesting scope for future research and model development.

**Future Research Directions:** Future research can use empirical longitudinal data, heterogeneous and spatial models, and regional policy analysis. Adding ROI, tariff optimization, and lifecycle costs can further strengthen the assessment of AI-driven EV business models.

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