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A Supply-Side Maturity Assessment of India's Electric Vehicle Industry: A SWOT–AHP-Based Framework

Abstract: - The transition to electric mobility in emerging economies is an integrated engineering system challenge that depends not only on consumer adoption but also on the maturity of domestic manufacturing, power system integration, and supporting infrastructure. This study presents a supply-side maturity assessment of India's electric vehicle (EV) industry through the development of an Electric Vehicle Industry Maturity Index (EVIMI) based on a hybrid SWOT–Analytic Hierarchy Process (AHP) framework. Sixteen critical factors influencing EV industrial readiness were identified through a systematic literature review and expert consultation. These factors were aggregated into four interdependent maturity dimensions: technology readiness, financial readiness, market readiness, and infrastructure readiness. The results were transformed into a normalized maturity index ranging from 0 to 1, where 0.5 represents a neutral transitional level. The findings reveal an asymmetric maturity profile: while market readiness is high, infrastructure readiness remains the primary binding constraint (index < 0.5), particularly regarding grid-side capacity and charging density. The study concludes that sustainable industrialization requires a shift from demand-side subsidies to system-level interventions in power distribution and technical manufacturing depth. The EVIMI framework provides a replicable diagnostic tool for evaluating industrial-technical readiness in other emerging EV ecosystems.

Keywords: Electric Vehicle Industry, SWOT-AHP, Maturity Index, Infrastructure Readiness, Power System Integration, Emerging Economies.

I. INTRODUCTION

Electric mobility is increasingly recognized as a critical component of sustainable transport transitions, particularly in emerging economies facing rising urban pollution, energy insecurity, and climate-change commitments [1], [2]. While electric vehicles (EVs) offer significant environmental and energy benefits, their large-scale deployment requires more than favorable consumer attitudes or policy incentives. The long-term success of EV transitions depends on the readiness of manufacturing capability, supply chains, financing mechanisms, and supporting infrastructure.

Existing EV research in developing countries has primarily focused on demand-side adoption, examining consumer preferences, willingness to pay, and the effectiveness of policy incentives [3], [4], [5]. Although these studies provide valuable insights into market behavior, they offer limited understanding of whether the underlying industrial ecosystem is capable of sustaining large-scale EV deployment. As EV adoption accelerates, weaknesses in manufacturing depth, infrastructure capacity, or financing availability may emerge as critical constraints.

India represents a particularly relevant context for examining EV ecosystem readiness. Despite ambitious national and state-level EV policies, reports consistently highlight gaps in charging infrastructure, grid resilience and domestic battery manufacturing capability [6], [7]. Similar challenges have been observed in other emerging EV markets, where market growth often outpaces the development of enabling supply-side systems [8], [9], [10].

Several EV readiness indices and benchmarking frameworks exist, but these largely emphasize adoption levels, policy ambition, or infrastructure density, with limited attention to supply-side industrial maturity. Technology-centric metrics such as Technology Readiness Levels (TRLs) assess innovation maturity but do not capture financial, market, or infrastructure dependencies [11]. Consequently, there remains a methodological gap in evaluating EV readiness as a multi-dimensional engineering system, particularly in emerging economies.

To address this gap, this study proposes an Electric Vehicle Industry Maturity Index (EVIMI) based on a hybrid SWOT–Analytic Hierarchy Process (AHP) framework. The framework integrates expert judgment with maturity-based normalization to evaluate EV ecosystem readiness across four dimensions: technology, finance, market, and infrastructure. By shifting the analytical focus from adoption outcomes to supply-side system readiness, the study contributes a structured diagnostic tool for evidence-based EV transition planning.

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II. LITERATURE REVIEW

A. *EV Transition as an Engineering Systems Challenge*

The global EV transition has evolved from a technology-centric narrative to a broader socio-technical systems challenge involving vehicles, energy systems, infrastructure, manufacturing capability, and policy coordination [8], [9]. Experiences from China, Europe, and the United States demonstrate that sustained EV growth depends on the co-evolution of industrial capacity and infrastructure rather than demand stimulation alone [12].

B. *Demand-Side EV Adoption Studies*

A large body of literature examines EV adoption through behavioral and economic lenses, identifying vehicle cost, driving range, charging convenience, and policy incentives as key determinants [12], [13], [14], [15]. In India, early studies emphasized high upfront costs and limited charging infrastructure as primary adoption barriers [6], [12]. While informative, these studies treat supply-side conditions largely as exogenous constraints.

C. *Supply-Side and Industrial Ecosystem Perspectives*

More recent research highlights the importance of battery supply chains, component localization, skilled manpower, and financing in shaping EV competitiveness [9], [16], [17]. Studies on China's EV ecosystem illustrate how coordinated industrial policy and infrastructure investment enabled rapid scaling [18]. In contrast, emerging economies continue to face fragmented supply chains and infrastructure deficits.

D. *Infrastructure and Energy System Readiness*

Charging infrastructure and grid capacity are consistently identified as critical enablers of EV adoption and utilization [7], [19]. However, most studies assess infrastructure readiness using single indicators, such as charger density, which fail to capture interactions with manufacturing, finance, and market conditions.

E. *EV Readiness and Maturity Frameworks*

Existing EV readiness indices focus primarily on adoption or policy ambition [20]. Maturity models used in Industry 4.0 and digital transformation assess readiness across interdependent dimensions and provide structured diagnostics [20], [21]. Such maturity-based approaches remain underutilized in national EV ecosystem assessments.

F. *SWOT–AHP and Hybrid MCDM Applications*

SWOT–AHP frameworks have been applied in energy planning, transportation strategy, and sustainability assessment to prioritize strategic factors [22], [23], [24], [25], [26], [27]. However, most applications focus on strategy selection rather than maturity diagnostics, leaving scope for methodological extension.

G. *Research Gap*

Three gaps emerge from the literature:

(1) limited assessment of EV readiness from a supply-side ecosystem perspective;

(2) absence of multi-dimensional maturity diagnostics integrating technology, finance, market, and infra-structure;

(3) limited extension of SWOT–AHP toward normalized maturity indices.

This study addresses these gaps by developing and applying the EVIMI framework.

III. METHODOLOGY

A. *Research Design and Framework Overview*

This study adopts a mixed qualitative–quantitative research design to assess the supply-side maturity of India's electric vehicle (EV) manufacturing and supply ecosystem. Rather than analysing consumer adoption or policy intent, the study focuses on diagnosing industry readiness as a multi-dimensional engineering system, comprising technological capability, financial depth, market conditions, and supporting infrastructure.

To achieve this objective, a hybrid SWOT–Analytic Hierarchy Process (AHP) framework is employed and extended into a maturity diagnostic tool termed the Electric Vehicle Industry Maturity Index (EVIMI). The methodological framework integrates qualitative identification of strategic factors with quantitative prioritization and aggregation, enabling systematic evaluation in contexts where empirical datasets are limited but expert knowledge is substantial. The overall methodological workflow consists of five sequential stages:

(i) identification of EV industry factors through literature review,
(ii) expert-based validation and classification of factors,
(iii) prioritization using AHP,
(iv) construction and normalization of maturity dimensions, and
(v) interpretation of maturity outcomes.

B. Identification of EV Industry Factors

A comprehensive review of peer-reviewed journal articles, policy documents, and industry reports published between 2014 and 2024 was conducted to identify factors influencing EV manufacturing and supply eco-systems in emerging economies. The review focused on technology development, supply chains, infra-structure readiness, financing mechanisms, and policy support relevant to EV industrialization. Based on this review and preliminary consultations with industry professionals, sixteen factors were identified and classified into four SWOT categories: Strengths (S1–S4), Weaknesses (W1–W4), Opportunities (O1–O4), and Threats (T1–T4). The identified factors were defined to ensure conceptual clarity and to minimize overlap, thereby enabling meaningful prioritization through pairwise comparison. Identification and Literature Validation of EV Industry Factors is placed at Table1.

Table 1. Identification and Literature Validation of EV Industry Factors

SWOT Factors	Name	Key Reference
Strength Factors	Access to Technology - S1	[28]
	Access to Components – S2	[29]
	Access to Skilled Manpower – S3	[30]
	Access to Finance – S4	[4]
Weakness Factors	Cost of Technology-W1	[10]
	Cost of Components-W2	[29]
	Cost of Skilled Manpower-W3	[30]
	Finance cost-W4	[31]
Opportunity Factors	Large Market Size -O1	[6]
	R&D on EV-O2	[6]
	Global Concern for Environment-O3	[32]
	Govt Subsidy and Tax Incentive-O4	[12]
Threat Factors	Lack of Charging Infrastructure-T1	[19] [33]
	Lack of Power Infrastructure-T2	[19] [33]
	High Electricity price-T3	[16]
	Alternate Technology-T4	[34]

The inclusion of explicit literature references for each factor ensures conceptual validity, while subsequent expert screening and prioritization provide contextual relevance to the Indian EV ecosystem.

C. Expert Selection and Data Collection

Primary data for factor prioritization were obtained through structured expert elicitation. A purposive sampling approach was adopted to select experts with direct and sustained involvement in the EV ecosystem. The selection criteria included:

(i) a minimum of ten years of professional experience in EV manufacturing, battery production, supply-chain management, or industry policy;
(ii) involvement in strategic, operational, or technical decision-making; and
(iii) familiarity with India's EV industrial and infrastructural context.

The final expert panel comprised six professionals representing battery manufacturing, EV production, procurement, supply-chain operations, and an EV industry association. Each expert independently performed pairwise comparisons of factors within each SWOT category using Saaty's nine-point scale. Responses were collected anonymously to reduce dominance and conformity bias.

Details of Experts Area and Experience is placed below at Table2.

Table 2. Experts Area and Experience

Designation	Area	Year of Experience
Head, Business Development & Projects	Electric Vehicle Battery Manufacturing	16 Years
Senior Manager, Supply Chain	EV Manufacturing	15 years
General Manager, Manufacturing	Indian EV Manufacturing	20 Years
Manager, Procurements	Indian Start-up EV Manufacturing	10 Years
Asst Director	Society of Manufacturer of Electric Vehicles	17 Years
Manager, Production	Indian EV Manufacturer	12 Years

D. Analytic Hierarchy Process (AHP) Formulation

The Analytic Hierarchy Process was employed to prioritise the identified SWOT factors. Let $A = [a_{ij}]$denote a pairwise comparison matrix of order n, where a_{ij}represents the relative importance of factor $i$over factor j, and $a_{ji} = 1/a_{ij}$.

The priority weight vector

$$\mathbf{w} = (w_1, w_2, \ldots, w_n)^T$$

is obtained by solving the eigenvalue problem:

$$A\mathbf{w} = \lambda_{\max}\mathbf{w}$$

where $\lambda_{\max}$is the maximum eigenvalue of matrix A. The normalized eigenvector corresponding to $\lambda_{\max}$yields the relative importance weights of the factors.

The consistency of expert judgments was assessed using the Consistency Index (CI):

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

and the Consistency Ratio (CR):

$$CR = \frac{CI}{RI}$$

where RI denotes the random index for a matrix of order n. A value of $CR \leq 0.10$ was considered acceptable, in line with established AHP guidelines. All pairwise comparison matrices in this study satisfied this criterion, indicating logically consistent expert judgments.

E. Aggregation of Expert Judgments

Since multiple experts participated in the evaluation, individual judgments were aggregated using the geometric mean, which is widely recommended for group decision-making in AHP-based studies. The aggregated comparison value $\bar{a}_{ij}$ is calculated as:

$$\bar{a}_{ij} = \left(\prod_{k=1}^{m} a_{ij}^{(k)} \right)^{1/m}$$

where $a_{ij}^{(k)}$ represents the judgment of expert k, and m is the number of experts. The resulting aggregated matrix was used to derive group-level priority weights following the standard AHP procedure.

F. Construction of EV Industry Maturity Dimensions

To translate prioritised factors into a maturity assessment, the weighted SWOT factors were grouped into four EV industry readiness dimensions:

1.Technology Readiness
2.Financial Readiness
3.Market Readiness
4.Infrastructure Readiness

Each dimension represents a critical subsystem of the EV supply ecosystem. Positive contributions were derived from strengths and opportunities, while constraining influences were represented by weaknesses and threats relevant to each dimension. Mapping of Maturity dimension with SWOT Factor is placed below at Table 3.

Table 3. Maturity Dimensions

Maturity Dimension	SWOT Factors Included (with sign)
Technology Readiness	+ S1 (Access to Tech) + S3 (Skilled Manpower) + O2 (R&D on EV) − W1 (Cost of Technology Acquisition) − W3 (Cost of Skilled Manpower)
Financial Readiness	+ S4 (Access to Finance) + O4 (Govt Incentives) − W4 (Cost of Finance)
Market Readiness	+ O1 (Large Market Size) + O3 (Global Environment Concern) − T4 (Alternate Technology)
Infrastructure Readiness	+ S2 (Access to Components) − W2 (Cost of Components) − T1 (Lack of Charging Infra) − T2 (Lack of Power Infra) − T3 (Electricity Prices)

G. Maturity Scoring and Normalization

For each maturity dimension d, a raw maturity score R_d was calculated as:

$$R_d = \sum w_i^+ - \sum w_j^-$$

where w_i^+ denotes the weights of enabling factors (strengths and opportunities) and w_j^- denotes the weights of constraining factors (weaknesses and threats) associated with dimension d.

To ensure interpretability and comparability across dimensions, raw scores were transformed into a normalized maturity index $M_d \in [0,1]$ using midpoint anchoring:

$$M_d = 0.5 + \frac{R_d}{4 \times \max(|R|)}$$

where $\max(|R|)$ is the maximum absolute raw maturity score observed across all dimensions. This normalization ensures that 0.5 represents a neutral or transitional level of readiness, values above 0.5 indicate relatively stronger maturity, and values below 0.5 indicate weaker maturity. The normalized scores collectively constitute the Electric Vehicle Industry Maturity Index (EVIMI).

For interpretability, the normalized Electric Vehicle Industry Maturity Index (EVIMI) scores are mapped to qualitative maturity levels reflecting system-level readiness. Scores below 0.50 indicate a critical level of maturity, characterized by fundamental infrastructural, technological, or power-system constraints that prevent reliable and scalable industry operation. Scores between 0.50 and 0.65 represent an emerging level of maturity, where initial system capabilities exist but remain insufficient for sustained large-scale deployment. Values between 0.65 and 0.80 indicate a developing level of maturity, reflecting improving system integration, partial infrastructure adequacy, and increasing operational stability. Scores above 0.80 correspond to a matured level of readiness, characterized by robust infrastructure, stable grid integration, and scalable manufacturing and market systems. The value of 0.50 is treated as a neutral threshold separating system immaturity from functional viability.

H. Methodological Validation and Robustness

The methodological robustness of the proposed framework is supported by established applications of SWOT–AHP hybrid models in energy systems, technology strategy, and sustainability assessment, where expert-based prioritization is appropriate in data-scarce environments [35], [36]. The use of AHP consistency ratios provides internal validation of expert judgments, while geometric mean aggregation ensures balanced group synthesis.

Furthermore, the normalization approach aligns with maturity-model practices commonly used in engineering and industrial systems, where relative readiness levels are interpreted using bounded indices rather than absolute scores [20], [21]. Together, these measures ensure that the proposed EVIMI framework is methodologically sound, transparent, and replicable, while remaining adaptable for future sensitivity analysis and cross-country application.

Although the present study does not perform a formal numerical sensitivity analysis, the structure of the EVIMI framework readily allows such extensions. In particular, variations in the weights of dominant factors—such as market size or infrastructure availability—would primarily affect the relative magnitude of maturity scores rather than the qualitative ordering of maturity dimensions. Given the clear separation observed between infrastructure readiness and other dimensions, moderate perturbations in individual factor weights are unlikely to alter the identification of infrastructure as the binding constraint. Future research may extend this work through systematic sensitivity or scenario analysis to examine the impact of alternative weighting assumptions.

IV. Analysis and Results

A. Overview of Analytical Procedure

This section presents the results obtained from the application of the SWOT–AHP framework and the construction of the Electric Vehicle Industry Maturity Index (EVIMI). The analysis proceeds in four stages:

(i) prioritization of SWOT factors using AHP,

(ii) ranking of factors based on global weights,

(iii) aggregation of factors into maturity dimensions, and

(iv) computation of normalized maturity scores for each dimension.

All results reported in this section are based on AHP-derived priority weights and normalized maturity scores, while interpretation and implications are discussed separately in Section 5.

B. Prioritization of SWOT Factors

Pairwise comparison matrices were developed for each SWOT category—Strengths, Weaknesses, Opportunities, and Threats—using aggregated expert judgments. Priority weights were derived using the eigen-vector method, and all matrices satisfied the consistency criterion (CR $\leqslant 0.10$), confirming the reliability of expert inputs. Across the four SWOT categories, opportunities received the highest group-level priority, followed by strengths, weaknesses, and threats. This indicates that experts perceive India's EV ecosystem as opportunity-rich, albeit constrained by internal and infrastructural limitations.

Within individual categories:

•Among strengths, access to technology and availability of skilled manpower received the highest weights.

•Among weaknesses, high cost of technology and high cost of components were the most dominant constraints.

•Among opportunities, large market size and global environmental concern were prioritized highest.

•Among threats, lack of charging infrastructure emerged as the most significant external constraint.

Detailed pairwise comparison matrices and consistency ratio results computed using Super Decision Software are provided in the Supplementary Material.

C. Global Ranking of EV Industry Factors

To assess the relative influence of individual factors across the entire EV ecosystem, local factor weights were multiplied by their respective group priorities to obtain global priority scores.

The results indicate that large market size ranks as the most influential factor overall, followed by access to technology and global environmental concern. Conversely, infrastructure-related constraints—particularly lack of charging infrastructure and power infrastructure limitations—rank among the most critical negative influences on industry readiness.

Table 4 presents the global ranking of all sixteen factors, providing a consolidated view of enabling and constraining forces shaping India's EV industry.

Table 4. Global Ranking of Factors

Group	Group Priority	Name	Normalized by Group	Rank Within Group	Limiting	Global Rank
Strength Factor	0.28920	Access to Technology - S1	0.47784	1	0.138192	2
		Access to Components – S2	0.18181	3	0.052580	9
		Access to Skilled Manpower – S3	0.23517	2	0.068013	6
		Access to Finance – S4	0.10518	4	0.030419	12
Weakness Factors	0.16780	Cost of Technology-W1	0.45978	1	0.077150	5
		Cost of Components-W2	0.25762	2	0.043229	10
		Cost of Skilled Manpower-W3	0.16106	3	0.027026	13
		Finance cost-W4	0.12154	4	0.020394	14
Opportunity Factors	0.41972	Large Market Size -O1	0.43064	1	0.180746	1
		R&D on EV-O2	0.18891	3	0.079291	4
		Global Concern for Environment-O3	0.24587	2	0.103196	3

		Govt Subsidy and Tax Incentive-O4	0.13458	4	0.056486	8
Threat Factors	0.12328	Lack of Charging Infrastructure-T1	0.47167	1	0.058146	7
		Lack of Power Infrastructure-T2	0.25615	2	0.031578	11
		High Electricity price-T3	0.16443	3	0.020270	15
		Alternate Technology-T4	0.10776	4	0.013284	16

D. Construction of EV Industry Maturity Dimensions

To translate factor-level priorities into a system-level assessment, the weighted SWOT factors were grouped into four maturity dimensions: technology readiness, financial readiness, market readiness, and infrastructure readiness. For each dimension, a raw maturity score was calculated by aggregating the weights of enabling factors (strengths and opportunities) and subtracting the weights of constraining factors (weaknesses and threats) associated with that dimension. These raw scores represent the balance between supportive conditions and structural constraints within each subsystem of the EV ecosystem.

E. Normalized EV Industry Maturity Index (EVIMI)

To enable intuitive interpretation and cross-dimensional comparison, raw maturity scores were normalized to a 0–1 scale, with 0.5 representing a neutral or transitional level of readiness. The resulting normalized scores constitute the Electric Vehicle Industry Maturity Index (EVIMI).

The normalized maturity scores for the four dimensions indicate:

•Technology Readiness: above the neutral threshold, reflecting developing technological capability supported by access to technology and skilled manpower.

•Financial Readiness: marginally above the neutral level, indicating emerging maturity with persistent financing constraints.

•Market Readiness: the highest among all dimensions, reflecting strong demand potential and favorable market conditions.

•Infrastructure Readiness: below the neutral threshold, indicating weak maturity driven by charging and power infrastructure deficits.

Table 5 summarizes the raw and normalized maturity scores across dimensions.

Table 5. Maturity Scores

Dimension	Calculation	Raw Score	Normalized Score
Technology Readiness	(+S1 +S3 +O2) − (W1 + W3) = (0.138192 + 0.068013 + 0.079291) − (0.077150 + 0.027026)	0.1813	0.67
Financial Readiness	(+S4 + O4) − W4 = (0.030419 + 0.056486) − 0.020394	0.0665	0.56
Market Readiness	(O1 + O3) − T4 = (0.180746 + 0.103196) − 0.013284	0.2707	0.75
Infrastructure Readiness	S2 − (W2 + T1 + T2 + T3) = 0.052580 − (0.043229 + 0.058146 + 0.031578 + 0.020270)	−0.1006	0.41

F. Graphical Representation of Maturity Levels

The normalized EVIMI scores were visualized using a radar chart to illustrate the relative maturity of the four dimensions. The chart highlights the asymmetric development of India's EV ecosystem, with market and technology readiness outperforming financial and infrastructure readiness.

This visual representation reinforces the diagnostic value of the proposed framework by clearly identifying infrastructure readiness as the weakest subsystem, relative to other dimensions.

Figure 1 presents the radar chart of normalized EVIMI scores.

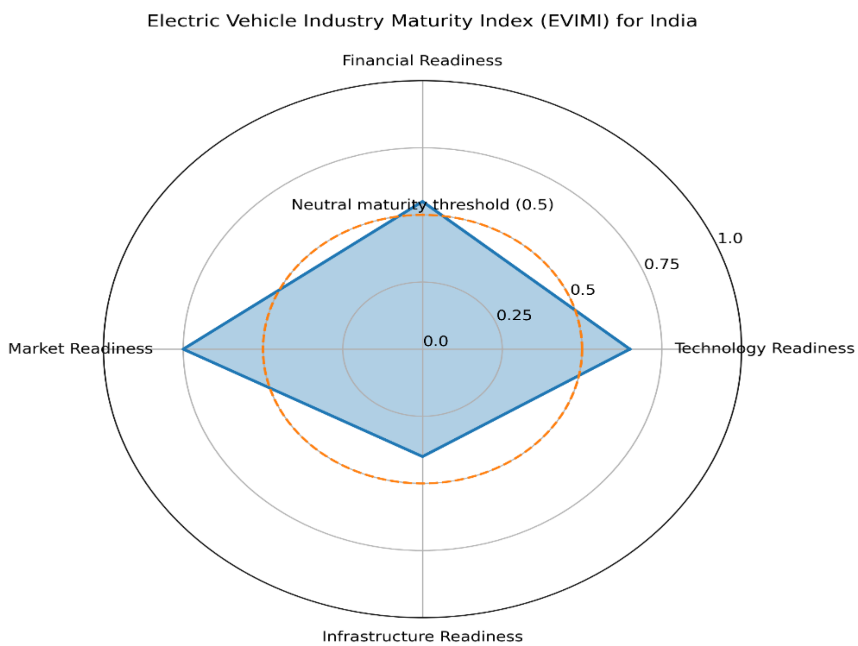

Figure 1. Radar chart of normalized Electric Vehicle Industry Maturity Index (EVIMI) scores across four readiness dimensions. The dashed circle represents the neutral maturity threshold (0.5), separating relatively mature and immature dimensions.

V. Discussion

A. Interpretation of EV Industry Maturity Results

The EV Industry Maturity Index (EVIMI) reveals an uneven pattern of readiness across the four assessed dimensions, reflecting structural imbalances within India's EV ecosystem. Market readiness exhibits the highest maturity level, indicating that demand-side conditions—driven by large market size and growing environmental awareness—are advancing more rapidly than supply-side capabilities. Technology readiness also demonstrates a developing level of maturity, supported by access to core EV technologies and the availability of skilled engineering manpower.

In contrast, financial readiness remains at an emerging level, suggesting that while policy incentives and private investment interest exist, access to affordable and scalable financing continues to constrain industrial expansion. The most critical finding is the relatively weak maturity of infrastructure readiness, driven by deficits in charging networks, grid capacity, and energy cost stability. This imbalance indicates that EV market growth in India is currently progressing faster than the development of enabling physical infrastructure.

B. Infrastructure Readiness: Grid Stability and Power System Integration

The assessment identifies infrastructure readiness as the primary binding constraint on India's EV industrialization. From a power systems perspective, this deficiency is not merely a matter of charger count but involves complex grid integration challenges. The results indicate that the current distribution network may face significant voltage instability and transformer congestion as stochastic EV charging loads increase.

Furthermore, the lack of high-power DC Fast Charging (DCFC) infrastructure limits the industry's ability to support heavy-duty and long-range transport segments. To transition from an "emerging" to a "mature" state, the ecosystem must move toward Smart Charging and Vehicle-to-Grid (V2G) technologies. These systems can mitigate peak-load contributions and offer ancillary services like frequency regulation, transforming EVs from a grid burden into a flexible energy resource. The maturity gap highlighted in this study suggests that without parallel investments in active power management and distribution automation, the rapid growth in market demand will outpace the grid's operational envelope.

C. Financial Readiness and Investment Asymmetry

The emerging level of financial readiness reflects a structural mismatch between capital requirements and available financing mechanisms. EV manufacturing and infrastructure development are characterized by high upfront costs, long payback periods, and evolving technology risks. While government incentives reduce some cost barriers, they do not fully address risk perception among lenders and investors, particularly for small and mid-sized firms.

The EVIMI framework captures this asymmetry by explicitly accounting for both access to finance and cost of capital. The results suggest that financial readiness lags not due to absence of capital, but due to misalignment between financial instruments and the risk profile of EV investments. Addressing this gap requires tailored financing mechanisms rather than broad-based incentives alone.

D. Contribution Beyond Adoption-Centric EV Studies

Most EV-related studies in the Indian context focus on consumer adoption, policy incentives, or charging behavior. While these studies provide valuable insights, they offer limited guidance on whether the underlying industrial ecosystem is capable of supporting large-scale and sustained EV deployment. The present study advances the literature by shifting the analytical focus toward supply-side industry maturity, evaluated as a system comprising interdependent subsystems.

By integrating SWOT analysis with AHP and extending it into a maturity diagnostic, this study moves be-yond factor ranking toward system-level readiness assessment. The dimension-specific maturity scores avoid the oversimplification inherent in single-index approaches and enable identification of targeted bottlenecks, particularly in infrastructure and finance.

E. Methodological Implications

From a methodological perspective, the study demonstrates that hybrid SWOT–AHP frameworks can be effectively adapted for maturity assessment, rather than being limited to strategic prioritization. The use of normalized maturity scores anchored around a neutral midpoint enhances interpretability and aligns the framework with established engineering maturity models.

Importantly, the framework is designed for expert-rich but data-scarce environments, a common characteristic of emerging industries and developing economies. This makes the EVIMI approach suitable for early-stage diagnostics, policy evaluation, and comparative benchmarking across regions or time periods.

F. Policy and Industry Implications

The maturity assessment suggests that accelerating EV adoption without parallel investment in infrastructure and financing mechanisms risks creating systemic inefficiencies. Policymakers should therefore prioritize infrastructure readiness—particularly charging density and grid resilience—alongside continued market stimulation. For industry stakeholders, the results highlight the importance of aligning technology investment decisions with infrastructure availability and financing conditions.

Rather than viewing EV transition as a linear progression from market creation to infrastructure development, the findings support a coordinated, system-oriented approach, where multiple readiness dimensions are advanced in parallel.

G. Transferability to Other Emerging Economies

Although empirically applied to India, the EVIMI framework is not country-specific. The underlying structure—technology, finance, market, and infrastructure readiness—is applicable to other emerging economies experiencing similar EV transition challenges. With appropriate contextualization of factors and expert inputs, the framework can be adapted for cross-country benchmarking and longitudinal assessment of EV ecosystem development.

VI. Conclusion

This study developed and applied an Electric Vehicle Industry Maturity Index (EVIMI) to assess the supply-side readiness of India's electric vehicle (EV) manufacturing and supply ecosystem. By integrating SWOT analysis with the Analytic Hierarchy Process (AHP) and extending it into a normalized maturity diagnostic, the study provides a structured framework for evaluating EV readiness as a multi-dimensional engineering system encompassing technology, finance, market conditions, and infrastructure.

The results reveal an asymmetric maturity profile across the four dimensions. Market readiness demonstrates the highest level of maturity, reflecting strong demand potential and favorable external drivers. Technology readiness also shows a developing level, supported by access to EV technologies and skilled engineering manpower. Financial readiness remains at an emerging stage, indicating persistent constraints related to cost of capital and financing access despite the presence of policy incentives. Most critically, infrastructure readiness exhibits the weakest maturity, underscoring charging and power infrastructure as binding constraints on sustained EV industrialization.

These findings highlight that India's EV transition is currently characterized by a misalignment between market expansion and enabling supply-side systems. The maturity assessment suggests that demand stimulation alone is insufficient unless accompanied by coordinated investments in infrastructure and financing mechanisms. From an engineering systems perspective, the results emphasize the need for parallel advancement across interdependent subsystems rather than sequential or isolated interventions.

Methodologically, the study extends the application of SWOT–AHP from strategic factor prioritization to maturity-based system diagnostics. The use of a normalized 0–1 maturity scale, anchored around a neutral midpoint, enhances interpretability while preserving analytical rigor. The framework is particularly suited to expert-rich, data-scarce contexts, making it applicable to other emerging economies undergoing early-stage EV transitions.

Overall, the proposed EVIMI framework contributes a transparent, replicable, and policy-relevant tool for benchmarking EV industry readiness, identifying systemic bottlenecks, and guiding phased transition strategies. While empirically applied to India, the framework can be readily adapted for comparative assessment across regions or over time, supporting evidence-based decision-making in the global transition toward sustainable mobility.

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