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Exploring Operational and Administrative Constraints in Electric Vehicle Manufacturing: Issues and Strategic Perspectives

Kaveri Dattatray Suryavanshi[1] and Dr. Mungi Ashlesha Ram[2]
Ph.D. Scholar, Department of Commerce, Savitribai Phule Pune University, Pune, India[1]
Research Supervisor, Department of Commerce, Savitribai Phule Pune University, Pune, India[2]
kaverimane3399@gmail.com and armungi2010@gmail.com

Abstract: *The Indian electric vehicle (EV) industry has moved from an experimental phase to a phase of commercial scale-up, with annual registrations crossing twenty-five lakh units and overall penetration touching approximately 8.5 per cent of total vehicle registrations in FY 2025-26. This growth, however, has not been matched by a proportionate maturing of the manufacturing base. Manufacturers continue to confront a dual burden: operational constraints arising from import dependence, thin supplier depth, capacity under-utilisation, skill shortages and validation infrastructure gaps; and administrative constraints arising from procedural complexity, delayed incentive disbursement, policy discontinuity, multi-agency clearances and compliance costs. The present study examines these two constraint domains in an integrated manner. Primary data were collected from 120 respondents drawn from EV original equipment manufacturers and auto-component units located in the Pune-Chakan-Chhatrapati Sambhajinagar industrial corridor of Maharashtra, using a structured five-point Likert scale instrument. The data were analysed through descriptive statistics, reliability testing, one-sample and paired-sample t-tests, one-way ANOVA and correlation analysis. The findings indicate that both operational and administrative constraints are perceived as significantly severe, that the difference between the two domains is not statistically significant, and that perceived severity varies inversely with firm size. Constraint severity is negatively correlated with capacity utilisation. The paper concludes with a set of strategic perspectives covering supply-chain de-risking, single-window administrative reform, predictable and time-bound incentive architecture, cluster-based shared testing facilities and skill formation, aimed at converting policy intent into manufacturing capability.*

Keywords: Electric vehicle manufacturing, operational constraints, administrative constraints, localisation, production-linked incentive, supply chain resilience, Indian automotive industry.

I. INTRODUCTION

Transport electrification has become a central instrument of India's energy security, industrial policy and climate commitments. Successive interventions — the National Electric Mobility Mission Plan 2020, the FAME I and FAME II schemes, the Production Linked Incentive (PLI) Scheme for Automobile and Auto Components, the PLI Scheme for Advanced Chemistry Cell (ACC) Battery Storage, and the PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) scheme — have created a demand-side pull and a supply-side push for domestic production, supplemented by capital subsidies, duty exemptions and land concessions under dedicated state EV policies.

The market response has been visible. In FY 2025-26 India registered approximately 25.5 lakh electric vehicles across categories, representing a year-on-year growth of about 24 per cent and an overall penetration of roughly 8.5 per cent of total vehicle registrations, up from 7.7 per cent in the preceding year. Electric two-wheelers accounted for close to 58 per cent of total EV volumes, the passenger three-wheeler segment recorded penetration in excess of 33 per cent, electric passenger cars grew by about 90 per cent to cross 2.2 lakh units, and the electric goods-vehicle segment expanded by around 172 per cent on a small base. On the face of it, therefore, the transition appears to be gathering pace.

Beneath these headline numbers, however, the manufacturing story is considerably more complicated. Growth in registrations is a demand-side outcome; it does not by itself establish that a resilient and value-adding domestic manufacturing ecosystem has been built. Traction motors remain almost wholly dependent on imported rare-earth permanent magnets; motor controller units and vehicle control units depend on imported semiconductors; and cell chemistry, cell manufacturing equipment and precursor materials continue to be sourced from a small number of overseas suppliers. These subsystems account for a substantial share of vehicle value, which means that a high nominal localisation percentage can coexist with a modest level of genuine domestic value creation.

The administrative environment presents a parallel set of difficulties. Incentive schemes that are generous in design have been slow in execution. Against a PLI-Auto outlay of ₹25,938 crore, cumulative disbursement stood at only about ₹2,386 crore by 31 March 2026, even though the scheme had catalysed investments of over ₹44,000 crore. Under the PLI-ACC programme, commissioned capacity has remained a small fraction of the awarded capacity. Demand incentives under PM E-DRIVE have been fund-limited and subject to shifting terminal dates and category-wise closures, which complicates production planning. Manufacturers must simultaneously satisfy domestic value addition certification, homologation requirements, battery waste obligations and a diverse set of state-level conditions.

These two categories of difficulty are usually studied separately. Operational constraints are treated as a supply-chain or production-management problem, while administrative constraints are treated as a policy or governance problem. In practice, manufacturers experience them jointly and often sequentially: a delayed clearance becomes a scheduling problem, a documentation requirement becomes a working-capital problem, and an import restriction becomes a line-stoppage problem. The present study therefore adopts an integrated framework and examines both domains together from the standpoint of the manufacturing unit.

II. REVIEW OF LITERATURE

2.1 Barriers to electric mobility

The early literature on Indian electric mobility was dominated by adoption studies. Digalwar and Giridhar (2015) applied interpretive structural modelling to the drivers of EV market development and placed government policy and infrastructure at the base of the hierarchy. Vidhi and Shrivastava (2018) argued that the environmental case for electrification in India is contingent upon grid decarbonisation and domestic battery capability. Kumar and Alok (2020) classified adoption barriers into technological, economic, infrastructural, social and policy-related categories, and observed that supply-side studies remained comparatively scarce.

2.2 Supply-side and manufacturing constraints

Tarei, Chand and Gupta (2021) modelled the interrelationship among adoption barriers in the Indian context and found that inadequate manufacturing and charging infrastructure exercised the strongest driving power over other barriers. Goel, Sharma and Rathore (2021) reviewed the technical and policy challenges of Indian electrification and identified battery cost, thermal management and localisation of power electronics as recurring bottlenecks. Industry-based analyses have reinforced these findings. The joint assessment by IEEFA and JMK Research (2026) concluded that although India could plausibly achieve 90 to 100 per cent localisation across several non-battery component categories by 2030, deeper value creation would depend on building upstream capability in semiconductors, rare-earth magnet processing and specialised materials, and noted that less than ten per cent of the PLI-Auto corpus had been disbursed by early 2026.

2.3 Administrative, regulatory and institutional constraints

A smaller body of work addresses the administrative dimension. Studies of incentive-linked industrial policy in India have highlighted the gap between sanction and disbursement, the transaction cost of compliance documentation, and the effect of policy discontinuity on investment confidence. The 332nd Report of the Parliamentary Standing Committee on Industry (2026) observed that coverage under PM E-DRIVE had been uneven across vehicle categories and that the ACC battery programme had commissioned only a fraction of awarded capacity, drawing attention to execution rather than design as the binding constraint. Bhattacharyya and Thakre (2021) and Khurana, Kumar and Sidhpuria (2020)

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show that policy credibility and perceived institutional support influence stakeholder attitudes as strongly as price and product attributes.

2.4 Research gap

Three gaps emerge from the literature. First, the demand side has been examined far more intensively than the supply side, and consumer perception studies substantially outnumber manufacturer-centred studies. Second, operational and administrative constraints are ordinarily analysed in isolation, so their relative severity and their joint effect on manufacturing performance remain under-examined. Third, most supply-side evidence is drawn from secondary sources, industry reports and expert interviews rather than from structured primary data collected at the level of the manufacturing unit, and micro, small and medium enterprises within the EV value chain are particularly under-represented. The present study addresses these gaps.

III. OBJECTIVES OF THE STUDY

- To identify and classify the major operational constraints encountered by electric vehicle manufacturing units in India.
- To identify and classify the major administrative and regulatory constraints encountered by such units.
- To assess and rank the perceived severity of these constraints and to compare the two constraint domains.
- To examine whether perceived severity differs significantly across categories of firm size.
- To examine the association between constraint severity and selected indicators of manufacturing performance.
- To suggest strategic perspectives for mitigating the identified constraints at the enterprise, industry and policy levels.

IV. HYPOTHESES OF THE STUDY

H 01: Operational constraints do not have a significant effect on the manufacturing performance of electric vehicle units.

H 02: Administrative constraints do not have a significant effect on the manufacturing performance of electric vehicle units.

H 03: There is no significant difference between the perceived severity of operational constraints and that of administrative constraints.

H 04: There is no significant difference in perceived constraint severity across categories of firm size.

V. RESEARCH METHODOLOGY

The study is descriptive and analytical in design and combines primary and secondary data. Secondary data were compiled from vehicle registration statistics, reports of the Ministry of Heavy Industries and the Parliamentary Standing Committee on Industry, publications of NITI Aayog and the Society of Indian Automobile Manufacturers, and independent research reports on EV localisation.

Primary data were collected from 120 respondents drawn from electric vehicle original equipment manufacturers, battery pack assemblers and Tier-I, Tier-II and Tier-III component units located in the Pune, Pimpri-Chinchwad, Chakan, Ranjangaon and Chhatrapati Sambhajinagar industrial belt of Maharashtra. A purposive sampling technique was adopted, since the population of units engaged specifically in EV-related manufacturing is limited and not exhaustively listed in any single frame. Respondents were plant heads, supply-chain managers, finance and administrative officers, and owner-directors.

A structured questionnaire was administered, comprising a profile section and two constraint batteries of ten statements each, measured on a five-point Likert scale where 1 denotes “not a constraint” and 5 denotes “a very severe constraint”. Manufacturing performance was captured through self-reported capacity utilisation and on-time delivery performance for the preceding financial year. The instrument was pilot-tested on fifteen units and refined for clarity. Data were analysed using descriptive statistics, Cronbach’s alpha, the Kaiser-Meyer-Olkin measure and Bartlett’s test of sphericity, one-sample and paired-sample t-tests, one-way analysis of variance and Karl Pearson’s coefficient of correlation. A five per cent level of significance was adopted throughout.

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Table 1: Segment-wise Electric Vehicle Registrations and Penetration in India

Segment	FY 2024-25 (units)	FY 2025-26 (units)	Growth (%)	Penetration FY26 (%)
Electric two-wheelers (E-2W)	11,49,000	14,74,000	28.3	6.6
Electric three-wheelers (passenger)	6,92,000	7,40,000	6.9	33.7
Electric passenger cars (E-4W)	1,17,000	2,22,870	90.4	4.6
Electric goods vehicles (N1–N3)	5,550	14,803	166.9	1.4
All categories (approx.)	20,50,000	25,50,865	24.4	8.5

Source: Compiled by the researchers from Vahan dashboard-based industry compilations, FY 2025-26. Figures are rounded and indicative.

VI. CONCEPTUAL FRAMEWORK OF CONSTRAINTS

For the purpose of this study, an operational constraint is defined as a limitation that arises within the production system and its immediate supply network, and that directly restricts the capacity of the unit to manufacture, assemble, validate or deliver output at the intended cost, quality and volume. An administrative constraint is defined as a limitation arising from the procedural, regulatory, fiscal and institutional environment external to the production system, which imposes delay, uncertainty or transaction cost upon the enterprise. The classification adopted is set out in Table 2.

Table 2: Classification Framework of Constraints in EV Manufacturing

Dimension	Operational Constraints	Administrative Constraints
Inputs	Import dependence for cells, magnets and semiconductors; thin domestic supplier base	Import licensing, tariff structure and domestic value addition certification
Process	Tooling and line reconfiguration cost; capacity under-utilisation; quality and thermal-safety failures	Homologation and type-approval lead time; multiplicity of testing agencies
People	Shortage of skilled manpower in power electronics, battery engineering and software	Absence of an accredited sector-specific skill and certification structure
Finance	Working-capital blockage in inventory; high cost of holding stock	Delayed disbursement of incentive claims; restricted access to institutional credit
Environment	Cell chemistry obsolescence; demand volatility and seasonality	Policy discontinuity; divergent state policies; battery waste and EPR compliance

Source: Developed by the researchers on the basis of literature review and pilot survey.

VII. DATA ANALYSIS AND INTERPRETATION

7.1 Profile of the respondent units

Table 3 presents the composition of the sample. Tier-I, Tier-II and Tier-III component manufacturers together account for approximately two-thirds of the sample, consistent with the structure of the Indian automotive value chain, in which component suppliers vastly outnumber vehicle assemblers.

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Table 3: Profile of Respondent Units (N = 120)

Parameter	Category	Frequency	Percentage
Type of unit	Original equipment manufacturer	22	18.3
	Tier-I component supplier	41	34.2
	Tier-II / Tier-III supplier	39	32.5
	Battery pack assembly unit	18	15.0
Vehicle segment served	Two-wheeler	46	38.3
	Three-wheeler	27	22.5
	Passenger car	29	24.2
	Bus and commercial vehicle	18	15.0
Size of the unit	Micro and small	44	36.7
	Medium	47	39.2
	Large	29	24.2
Experience in EV operations	Less than 3 years	38	31.7
	3 to 5 years	52	43.3
	More than 5 years	30	25.0

Source: Primary data.

7.2 Reliability and validity of the instrument

The internal consistency of the two constraint batteries was tested using Cronbach's alpha. The operational battery returned a coefficient of 0.874 and the administrative battery a coefficient of 0.861, with an overall value of 0.902 for the combined twenty statements. All values exceed the conventional threshold of 0.70, confirming that the instrument is reliable. The Kaiser-Meyer-Olkin measure of sampling adequacy stood at 0.836 and Bartlett's test of sphericity was significant ($\chi^2 = 1284.63$, $p < 0.001$), indicating that the data were suitable for further multivariate treatment.

7.3 Severity of operational constraints

Table 4 reports the mean severity score, standard deviation and rank of each operational constraint. A mean above 4.00 may be read as a severe constraint, between 3.50 and 4.00 as moderately severe, and below 3.50 as a constraint of lower intensity.

Table 4: Mean Severity and Ranking of Operational Constraints (N = 120)

Operational constraint	Mean	S.D.	Rank
Dependence on imported cells and battery raw materials	4.42	0.61	1
Disruption in supply of rare-earth magnets and traction motors	4.31	0.68	2
Shortage of automotive-grade semiconductors and controllers	4.18	0.72	3
Low capacity utilisation caused by demand volatility	4.06	0.77	4
High cost of tooling, fixtures and line reconfiguration	3.97	0.74	5
Shortage of skilled manpower in power electronics and software	3.89	0.81	6
Inadequate local supplier base for high-voltage components	3.78	0.85	7
Quality failures, thermal safety issues and field returns	3.64	0.88	8
Blockage of working capital in inventory and buffer stock	3.55	0.91	9
Inadequate in-house testing and validation infrastructure	3.41	0.94	10
Composite operational constraint score	3.92	0.58	—

Source: Primary data.

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The four highest-ranked operational constraints relate to input security rather than to internal process efficiency. Respondent units do not report that they are unable to manufacture, but that they are unable to secure predictable inputs at predictable prices. The lowest-ranked items — inventory blockage and in-house validation capacity — are, in effect, consequences of the higher-ranked items, since buffer stocks are accumulated precisely because upstream supply is uncertain.

7.4 Severity of administrative constraints

Table 5: Mean Severity and Ranking of Administrative Constraints (N = 120)

Administrative constraint	Mean	S.D.	Rank
Delay in disbursement of incentive and subsidy claims	4.37	0.64	1
Frequent changes in policy norms, caps and terminal dates	4.25	0.70	2
Complexity of domestic value addition certification and documentation	4.11	0.73	3
Multiplicity of approving authorities at Centre and State level	3.98	0.79	4
Lead time in homologation and type approval	3.86	0.82	5
Divergence among State electric vehicle policies	3.74	0.86	6
Delay in land, power connection and environmental clearances	3.62	0.89	7
Compliance cost of battery waste and EPR obligations	3.49	0.92	8
Restricted access to institutional finance for EV projects	3.38	0.95	9
Weak grievance redressal and industry feedback mechanism	3.27	0.97	10
Composite administrative constraint score	3.81	0.61	—

Source: Primary data.

The pattern within the administrative domain mirrors that of the operational domain. The three highest-ranked constraints — disbursement delay, policy volatility and certification complexity — concern predictability rather than the adequacy of support. Respondents did not report that incentives are insufficient in design, but that their timing and continuity cannot be relied upon for production and investment planning. This corresponds with the secondary evidence that cumulative PLI-Auto disbursement had reached only about nine per cent of the sanctioned outlay by the close of FY 2025-26.

7.5 Testing of hypotheses

A one-sample t-test was applied against a test value of 3, the neutral point of the scale (Table 6).

Table 6: One-Sample t-Test for Constraint Severity (Test Value = 3)

Constraint domain	Mean	S.D.	df	t-value	Sig. (2-tailed)
Operational constraints	3.92	0.58	119	11.86	0.000
Administrative constraints	3.81	0.61	119	10.42	0.000

Source: Primary data.

Since the significance values are below 0.05 in both cases, the null hypotheses H 01 and H 02 are rejected. Both operational and administrative constraints are perceived to exert a significant adverse effect on manufacturing performance.

A paired-sample t-test was then applied to compare the two domains. The mean difference of 0.11 produced a t-value of 1.86 with 119 degrees of freedom and a significance value of 0.065, which exceeds 0.05. The null hypothesis H 03 is therefore accepted. Operational and administrative constraints are perceived with broadly comparable severity, and no case can be made for treating one domain as materially more binding than the other. This finding has a direct policy implication: interventions that address only supply-chain issues, or only procedural issues, are unlikely to be adequate.

One-way analysis of variance was used to test whether perceived severity differs across firm size. The results are presented in Table 7.

Table 7: One-Way ANOVA of Composite Constraint Severity across Firm Size

Source of variation	Sum of squares	df	Mean square	F	Sig.
Between groups	3.842	2	1.921	6.42	0.002
Within groups	35.012	117	0.299	—	—
Total	38.854	119	—	—	—

Source: Primary data. Group means: micro and small units 4.08; medium units 3.87; large units 3.61.

The F-value of 6.42 is significant at the one per cent level, and H 04 is rejected. Perceived severity declines consistently as firm size increases. Larger units possess the balance-sheet capacity to hold buffer inventory, the internal expertise to prepare incentive documentation and the negotiating strength to secure supplier allocations. Micro and small units possess none of these and absorb the same external shocks with substantially greater difficulty.

Finally, correlation analysis was undertaken between composite constraint severity and two performance indicators. The coefficient between constraint severity and capacity utilisation was −0.58, and that between constraint severity and on-time delivery performance was −0.49, both significant at the one per cent level. The negative and moderately strong association confirms that the constraints identified are not merely a matter of managerial perception but are reflected in measurable operating outcomes.

VIII. MAJOR FINDINGS

- Import dependence for cells, rare-earth magnets and automotive semiconductors emerged as the single most severe operational constraint, with a mean score of 4.42, indicating that input security rather than production capability is the binding limitation.
- Delay in the disbursement of incentive claims was ranked as the most severe administrative constraint, with a mean score of 4.37, corroborated by secondary evidence that cumulative PLI-Auto disbursement reached only about ₹2,386 crore against an outlay of ₹25,938 crore by 31 March 2026.
- Policy discontinuity — shifting terminal dates, category-wise closures and fund-limited incentives — was ranked second within the administrative domain and was reported as a direct impediment to production planning.
- There is no statistically significant difference between the severity of the two constraint domains, indicating that they must be addressed jointly rather than sequentially.
- Perceived severity varies inversely and significantly with firm size, with micro and small units reporting a composite score of 4.08 against 3.61 for large units.
- Constraint severity is negatively correlated with capacity utilisation ($r = -0.58$) and with on-time delivery performance ($r = -0.49$), both significant at the one per cent level.

IX. STRATEGIC PERSPECTIVES AND SUGGESTIONS

9.1 De-risking the input supply chain

Since four of the five most severe operational constraints concern input security, the highest priority is diversification and partial domestication of critical inputs. This requires a dedicated incentive structure for rare-earth processing and magnet manufacture calibrated to close the landed-cost gap against imports rather than merely to subsidise capital expenditure. In the interim, expanding sourcing arrangements with alternative supplier countries and accelerating the qualification of magnet-free motor architectures, such as wound-rotor and ferrite-assisted synchronous reluctance machines, can reduce exposure. A strategic reserve of critical materials also merits consideration.

9.2 Reforming the administrative interface

A genuine single-window mechanism for EV manufacturing approvals, integrating central and state clearances with statutory timelines and deemed approval provisions, would address multi-agency dependence. Domestic value addition certification should be simplified through standardised templates, accredited third-party verification and digital submission, so that the compliance burden does not fall disproportionately on smaller units without dedicated regulatory staff.

9.3 Predictable and time-bound incentive architecture

The evidence indicates that the credibility of an incentive matters as much as its quantum. Schemes should therefore specify a statutory outer limit for claim settlement, publish claim-level disbursement dashboards, and provide advance notice before the modification or closure of any category. Where fund limits are binding, a transparent utilisation tracker would allow manufacturers to plan production rather than react to the sudden exhaustion of funds. Permitting the discounting of verified but unpaid incentive receivables through designated financial institutions would further neutralise the working-capital consequence of delay.

9.4 Cluster-based shared infrastructure

Because inadequate testing and validation capacity affects small units most acutely, shared facilities established on a cluster basis — covering battery abuse testing, electromagnetic compatibility, durability testing and prototype tooling — would materially lower the entry threshold. Existing clusters in Maharashtra, Tamil Nadu, Gujarat, Karnataka and Haryana provide a ready foundation for such common facility centres, co-funded under MSME cluster development provisions.

9.5 Skill formation and technology capability

The shortage of manpower in power electronics, battery systems and embedded software should be addressed through structured collaboration between industry, the Automotive Skill Development Council and technical institutions, involving curriculum co-design, industry internships and recognition of prior learning for workers migrating from internal combustion engine production. Firm-level investment in design capability, as distinct from assembly capability, is essential if localisation is to translate into genuine value creation.

9.6 Enterprise-level strategies

- Adopting dual sourcing and supplier development programmes for all critical components rather than relying on a single overseas source.
- Modular and platform-based product design that permits substitution of cell formats and motor types without complete line reconfiguration.
- Formal risk registers and scenario planning for input disruption, with defined trigger points and contingency actions.
- Participation in industry associations for collective representation on policy design and for aggregated procurement of scarce inputs.

X. CONCLUSION

The Indian electric vehicle industry has established demand. It has not yet established manufacturing resilience. The evidence assembled here indicates that manufacturers are constrained less by their ability to produce than by their ability to secure inputs predictably and to navigate an administrative environment marked by procedural complexity, delayed settlement and shifting rules. The analysis establishes that both constraint domains are significantly severe, that neither dominates the other, that smaller enterprises bear a disproportionate share of the burden, and that constraint severity translates into measurable losses in capacity utilisation and delivery reliability.

The strategic response must therefore be simultaneous rather than sequential. Supply-chain de-risking without administrative reform will leave manufacturers with secure inputs and unpredictable cash flows; administrative reform without upstream capability building will leave them with efficient paperwork and vulnerable production lines. The transition from a policy-driven market to an industry-driven one will depend on how effectively these two agendas are pursued together, and on whether the smallest participants in the value chain are equipped to survive the transition rather than being displaced by it.

XI. LIMITATIONS AND SCOPE FOR FURTHER RESEARCH

The study is confined to a purposively selected sample of 120 units located in one industrial corridor of Maharashtra, and the findings should therefore be generalised with caution. Constraint severity has been measured through perceptual, self-reported data, and the performance indicators used are self-declared rather than audited. Future research may extend the enquiry to a multi-state sample, incorporate longitudinal data to capture the effect of successive policy

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revisions, apply structural equation modelling to test causal pathways between constraint domains and performance, and undertake comparative analysis with other emerging EV manufacturing economies.

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