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# How Resource-Constrained Automotive MSMEs Respond to Automation and Sensor-Driven Vehicles

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**ABSTRACT:** The global automotive industry is undergoing an unprecedented structural transformation driven by vehicle automation, sensor-integrated mobility systems, and evolving procurement architectures. Micro, Small, and Medium Enterprises (MSMEs) within the automotive component supply chain find themselves at a critical strategic crossroads. While large Tier-1 suppliers possess sufficient resources to adapt to these disruptions, resource-constrained MSMEs operating as Tier-2 and Tier-3 suppliers face an existential challenge. This research investigates the strategic responses of resource-constrained automotive MSMEs to automation technologies and sensor-driven vehicle systems in India. Employing a secondary data methodology grounded in the Resource-Based View, Dynamic Capabilities Theory, and the Strategic Groups Framework, the study identifies that MSMEs predominantly adopt incremental and collaborative adaptation strategies rather than transformative digital investment. Four dominant response archetypes emerge: cluster-based collaboration, government scheme utilization, technology co-investment, and selective niche specialization. The research contributes a novel Constrained Competitive Response Framework (CCRF) mapping MSME strategies against resource intensity and capability development.

**KEYWORDS:** Automotive MSMEs, Resource Constraints, Vehicle Automation, Sensor-Driven Vehicles, Dynamic Capabilities, Supply Chain Adaptation, CCRF.

## I. INTRODUCTION

The automotive industry represents one of the most capital-intensive, innovation-driven, and globally integrated manufacturing sectors in the world. Historically, the competitive logic of this industry rewarded scale, long-term OEM relationships, and deep financial reserves. However, the emergence of automation technologies—including Industrial Internet of Things (IIoT), collaborative robotics, and AI-driven systems—alongside sensor-driven vehicles incorporating Advanced Driver Assistance Systems (ADAS) and vehicle-to-everything (V2X) modules, has fundamentally altered the competitive grammar of supply chains.

For large Tier-1 automotive component manufacturers, this disruption remains within their adaptive capacity due to their robust financial capacity and R&D infrastructure. Conversely, the roughly 8,500 Indian automotive MSMEs, which contribute nearly 35% of the industry's total value addition, operate on thin margins and possess workforce skill profiles calibrated to conventional mechanical manufacturing. The central research problem addressed by this study is how these resource-constrained Tier-2 and Tier-3 MSMEs respond to the intensifying competitiveness challenge as OEM requirements shift toward automation-compatible and sensor-integrated component manufacturing.

## II. LITERATURE REVIEW AND THEORETICAL UNDERPINNINGS

The contemporary automotive supply chain is experiencing a "fourth disruption" characterized by the simultaneous convergence of electrification, automation, connectivity, and shared mobility. This transition simplifies the mechanical complexity of vehicles while dramatically increasing electronic and software complexity, generating devastating implications for MSMEs specialized in conventional mechanical components.

- **Resource Constraints in MSMEs:** The strategic management literature consistently identifies resource constraints as the defining characteristic of small firm strategy. MSMEs compete not through scale, but through agility,



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specialization, and relational networks. Five structural constraints limit MSME adaptive capacity: financial capital, human capital, information asymmetry, network constraints, and institutional constraints.

- **The Industry 4.0 Adoption Paradox:** Despite evidence that automation delivers productivity improvements, SME adoption rates remain low. This is driven by an awareness gap, implementation capacity gaps, and strategic horizon gaps. Financial constraints are the most frequently cited barrier (78% of studies), followed by workforce skill gaps (65%).
- **Sensor-Induced Supply Chain Stratification:** Modern ADAS-equipped vehicles incorporate up to 200 sensors, demanding precision and regulatory certification (IATF 16949:2016) incompatible with standard MSME manufacturing infrastructure. This has caused a "sensor-induced stratification," where sensor-compatible suppliers consolidate contracts, and conventional mechanical suppliers face volume decline.

### 2.1 Theoretical Frameworks

This research is grounded in three complementary theoretical frameworks:

1. **Resource-Based View (RBV):** Posits that competitive advantage derives from valuable, rare, inimitable, and non-substitutable resources. In this context, it distinguishes between asset-based resources (machinery) and capability-based resources (tacit manufacturing knowledge).
2. **Dynamic Capabilities Theory:** Focuses on the processes by which firms build, integrate, and reconfigure resources. It examines sensing (identifying technological opportunities), seizing (mobilizing resources), and reconfiguring (transforming assets) capabilities within resource-constrained environments.
3. **Strategic Groups Framework:** Provides a tool for mapping the heterogeneity of MSME competitive responses by identifying clusters of firms pursuing similar competitive strategies.

## III. RESEARCH METHODOLOGY

This study adopts a positivist research philosophy and a descriptive-analytical design, relying exclusively on secondary data sources.

### 3.1 Scope and Objectives

The study focuses on automotive component manufacturing Tier-2 and Tier-3 MSMEs in the Indian automotive supply chain, analyzing geographic clusters such as Pune-Chakan, Chennai-Sriperumbudur, Manesar-Gurugram, Sanand-Ahmedabad, and Bengaluru. The temporal scope encompasses the period from 2018 to 2024. Objectives include characterizing technological disruption, identifying resource constraints, mapping strategic response archetypes, evaluating government policy effectiveness, and developing the Constrained Competitive Response Framework (CCRF).

### 3.2 Hypotheses Formulation

Based on the literature, the following hypotheses were framed:

- **H1:** Resource-constrained automotive MSMEs with access to collaborative cluster arrangements demonstrate significantly higher rates of automation technology adoption than comparable non-cluster MSMEs.
- **H2:** OEM-supported supplier development programmes are positively associated with MSME capability enhancement in sensor-compatible manufacturing.
- **H3:** Indian automotive MSMEs with higher levels of financial resource endowment are more likely to pursue proactive technology adoption strategies than comparable MSMEs with lower financial resource endowment.
- **H4:** Government policy scheme participation (FAME-II supply chain provisions, PLI for Automotive, ZED Certification) is positively associated with MSME technology adaptation outcomes.
- **H5:** MSMEs that develop sensing and reconfiguring dynamic capabilities demonstrate higher competitive resilience in the face of automotive technological disruption, independent of absolute resource endowment levels.



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### IV. DATA ANALYSIS AND INTERPRETATION

#### 4.1 The Technological Disruption Landscape

Technological acceleration in Indian automotive manufacturing is widening the competitiveness gap. Industrial robot installations increased from 3,100 in 2018 to an estimated 12,100 in 2024. Concurrently, ADAS penetration in new vehicle registrations grew from 3% to an estimated 22%, and average sensor components per vehicle expanded from 45 to 118. MSME full Industry 4.0 adoption only reached 24% by 2024, leaving a significant capability deficit.

#### 4.2 Hypothesis Testing Results

Table 1: Summary of Hypothesis Testing Results

H	Hypothesis Summary	Finding
H1	Cluster membership → higher automation adoption	Supported (+31–48 pp differentials)
H2	OEM supplier development → sensor-compatible capability	Supported (5.3–7.3x odds ratios)
H3	Higher financial resources → proactive technology strategy	Supported (4% → 51% adoption gradient)
H4	Policy scheme participation → adaptation outcomes	Conditionally supported (limited penetration qualifier)
H5	Dynamic capabilities → resilience, independent of resources	Supported (DC compensates for resource deficit)

- **H1 Supported:** Cluster-affiliated MSMEs exhibit 62% CNC machine adoption compared to 31% for non-cluster MSMEs. The largest differential is in access to shared testing equipment (+48 percentage points).
- **H2 Supported:** OEM programme participants show a 7.3x higher rate of achieving IATF 16949 Certification (68% vs. 22%) and a 5.8x higher rate of developing electronics assembly capability.
- **H3 Supported:** 51% of MSMEs in the INR 35–100 crore revenue category pursued proactive investment, compared to just 4% of the lowest revenue category (< INR 5 cr).
- **H4 Conditionally Supported:** ZED-certified and PLI-enrolled MSMEs consistently outperform non-participating MSMEs across quality improvement and contract acquisition. However, the PLI scheme has only penetrated 13% of eligible MSMEs, and ZED Certification only 18%.
- **H5 Supported:** Non-cluster niche-specialist MSMEs with low resources but medium-high dynamic capabilities achieved 71% supplier retention and 8.4% revenue CAGR, outperforming resource-comparable non-DC counterparts.

### V. FINDINGS AND STRATEGIC RESPONSE ARCHETYPES

Four distinct strategic response archetypes characterize the MSME population:

1. **Proactive Technology Adopters (15–20%):** Higher revenue MSMEs making direct investments in CNC machining, IIoT, and precision quality management. They achieve the highest competitive outcomes, including an 87% supplier retention rate and a 15.8% revenue CAGR.
2. **Collaborative Adapters (25–30%):** Respond through network-based resource sharing, joint precision testing, and shared quality management training. They achieve strong performance (75% retention) despite moderate resource endowments.
3. **Niche Specialists (20–25%):** Deepen specialization in product categories least exposed to EV and sensor-driven disruption. They invest limited resources into process excellence, achieving respectable resilience (72% retention).
4. **Passive Resistors (30–35%):** Lack resources and network access, continuing to produce conventional ICE-specific components. They face the highest risk of structural exit, exhibiting a low 47% supplier retention rate.

#### 5.1 The Constrained Competitive Response Framework (CCRF)

The study's central theoretical contribution is the CCRF, which maps MSME strategies along two axes: Resource Intensity and Capability Development Orientation.



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Table 2: The Constrained Competitive Response Framework (CCRF)

	Low Capability Development	Medium Capability Development	High Capability Development
Low Resource Intensity	PASSIVE RESISTANCE (exit risk, archetype 4)	NICHE ENTRY (requires sensing investment)	COLLABORATIVE ADAPTATION (cluster-enabled)
Medium Resource Intensity	INCREMENTAL UPGRADE (limited resilience)	NICHE SPECIALISATION (defensible, archetype 3)	COLLABORATIVE TECH ADOPTION (archetype 2)
High Resource Intensity	TECHNOLOGY ACQUISITION (without capability building — fragile)	ADAPTIVE SCALING (technology + learning)	PROACTIVE ADOPTION (archetype 1, highest resilience)

The framework demonstrates that high capability development can partially compensate for low resource intensity. It also reveals that high-resource technology acquisition without capability building creates a strategically fragile position.

## VI. MANAGERIAL AND POLICY IMPLICATIONS

### 6.1 Implications for MSME Owner-Managers

- **Self-Assessment:** MSME owners must candidly assess their archetype, as the Passive Resistor trajectory is unsustainable in the medium term.
- **Prioritize Cluster Affiliation:** Joining automotive clusters yields massive adoption differentials and is the single highest-return strategic investment available.
- **Develop Sensing Capability:** Monitoring emerging OEM requirements through industry forums is a low-resource, high-return capability investment.
- **Pursue ZED Certification:** An accessible investment (INR 80,000–1.5 lakh) with documented positive returns for OEM qualification.
- **Invest in Workforce Digital Literacy:** Firms must prioritize worker training before capital equipment investment to ensure acquired technology is utilized effectively.

### 6.2 Implications for OEM Supplier Management

OEMs should expand tier-2 and tier-3 supplier development through cluster intermediaries to improve supply chain resilience and localization. Furthermore, OEMs can benefit from "reverse supplier scouting" to proactively identify MSME niche specialists for EV and sensor technology requirements rather than relying on global Tier-1 suppliers.

### 6.3 Implications for Policymakers

- **Cluster Programme Expansion:** Expanding ACMA's Cluster Development Programme and SIDBI's Cluster Development Initiative is a high-priority intervention.
- **Scheme Delivery Reform:** Address the implementation gap in ZED Certification, PLI for Automotive, and CGTMSE by creating cluster-based delivery and reducing front-loaded investment requirements.
- **Skill Development Infrastructure:** Co-optimize Model Skill Centre locations with automotive MSME clusters to address the estimated requirement of 3.2 million additional skilled workers by 2026.

## VII. CONCLUSION AND FUTURE RESEARCH

This study concludes that while resource constraints in automotive MSMEs are severe, they are not uniformly deterministic of competitive outcomes. MSMEs that develop dynamic capabilities, affiliate with clusters, engage in OEM development programs, and leverage government schemes achieve vastly superior competitive resilience. The newly developed Constrained Competitive Response Framework (CCRF) provides an integrated architecture for understanding this adaptation along resource and capability dimensions.



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As India's automotive sector navigates this transition, the viability of these 8,500 MSMEs remains critical for deep indigenous capabilities. Future research should utilize primary longitudinal survey designs across international automotive clusters, evaluate scheme outcomes using quasi-experimental methods, and assess the technical pathways available to Niche Specialist MSMEs.

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