

# “IOT Adoption in Manufacturing MSMEs of India: A Review of Barriers, Opportunities and Policy Landscape”

Supriya Prasad Daware<sup>1</sup>, Dr. Nitin Sopan Bhand<sup>2</sup>

<sup>1</sup>Research Scholar, Amrutvahini Institute of Management and Business Administration, Sangamner.

<sup>2</sup>Associate Professor, Amrutvahini Institute of Management and Business Administration, Sangamner

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## ABSTRACT

The adoption of Industrial Internet of Things (IIoT) technologies among manufacturing Micro, Small and Medium Enterprises (MSMEs) in India remains remarkably low despite a decade of government promotion. This paper reviews academic studies, government reports, and news articles published between 2018 and 2025 to understand the barriers to IIoT adoption in this sector. The review identifies four interconnected categories of barriers: technological (outdated machinery, poor connectivity), organizational (digital skill shortages, low awareness of government schemes), financial (credit gap of ₹80 lakh crore, high upfront costs), and environmental (underdeveloped vendor ecosystems, policy implementation gaps). Despite these barriers, documented success stories demonstrate that IIoT adoption is both feasible and beneficial. One study achieved 22.5% reduction in cycle time and 71.43% reduction in errors with an investment of INR 1.3 lakh. Industry reports document 20-25% improvements in efficiency and 35% reduction in defects among early adopters. The paper concludes that while the technology works and the costs are affordable for many medium enterprises, adoption remains low due to interacting barriers that no single policy or intervention can address alone.

**Keywords:** Industrial Internet of Things, IIoT, MSME, manufacturing, India, technology adoption, barriers

## INTRODUCTION

### Background

The Indian government has been talking about Industry 4.0 for nearly a decade. "Make in India," "Digital India," "Smart Cities Mission" the list goes on. But here is the uncomfortable truth. A recent NITI Aayog-backed report found that 82% of medium enterprises in India do not use advanced technologies like AI or IoT in their operations. Worse, 60% still rely on outdated machinery that hurts their productivity and product quality (Administrative Staff College of India, 2025). Think about what this means. Millions of workers. Billions in potential output. India's dream of becoming a global manufacturing hub. All stuck because old machines cannot talk to new software. The Indian IoT in manufacturing market was worth INR 422.57 billion in FY 2022 and is expected to reach INR 774.90 billion by FY 2027, growing at over 13% annually (India Smart Manufacturing Report, 2024). The opportunity is enormous. So why are MSMEs not grabbing it?

### Scope of Study

This paper reviews existing literature to understand why manufacturing MSMEs in India struggle to adopt Industrial Internet of Things (IIoT) technologies. The MSME sector contributes about 29% to India's GDP, accounts for roughly 40% of exports, and employs over 60% of the workforce (NITI Aayog, 2025). But here is a number that surprised me: 97% of registered MSMEs are micro enterprises, 2.7% are small, and only 0.3% are medium enterprises. Yet that tiny 0.3% contributes nearly 40% of all MSME exports (Administrative Staff College of India, 2025). These medium enterprises are the unsung heroes of Indian manufacturing. Research shows that IIoT can enable real-time production monitoring, predictive maintenance, quality control, and supply

chain optimization (Shah, Madni, Hashim, Ali, & Faheem, 2024). What we do not fully understand is why these critical medium enterprises have not adopted these technologies despite clear benefits and government support.

### **Need of the study**

This review is needed for several reasons. First, the financial gap is staggering. One report estimates that only 19% of MSME credit demand is currently being met (Institute for Competitiveness, 2025). Without understanding what barriers these firms actually face, policymakers are shooting in the dark. Second, the human side of adoption has been ignored. A 2024 study found that when researchers included "human factors" in their analysis - employee skills and attitudes - eight out of twelve hypotheses were supported (Mukherjee, Baral, Chittipaka, Nagariya, & Patel, 2024).

This tells us that technology alone is not the answer. Third, the gap between policy and practice is embarrassing. Only 10% of medium enterprises have used any of the 18 schemes offered by the Ministry of MSME (Administrative Staff College of India, 2025). This is not because the schemes are bad. It is because nobody knows about them or the application process is too complicated. Fourth, the success stories that do exist - like an automotive parts manufacturer that cut machine downtime by 20% and maintenance costs by 15% - prove that IIoT works (NASSCOM Community, 2024). But these remain exceptions, not the rule.

### **Research Gap and Questions**

Despite growing attention to Industry 4.0, our understanding of IIoT adoption in Indian manufacturing MSMEs has serious gaps. Most studies focus on large firms or developed countries. A 2022 study that used expert opinions from Delhi NCR found that data security and technology reliability were the top challenges (Kumar, Sindhwani, & Singh, 2022).

But can we generalize from just one region? Researchers have identified multiple barriers, but very few have examined how these barriers interact and amplify each other. We also have very little documented evidence of what actually works. The smart assembly cell project that achieved 22.5% cycle time reduction and 71% error reduction for INR 1.3 lakh is a rare exception (Patil, Patil, & Kulkarni, 2025). This paper addresses these gaps by asking five questions:

- (1) What barriers do manufacturing MSMEs face?
- (2) How do these barriers interact?
- (3) What happens when MSMEs successfully adopt IIoT?
- (4) What policies exist and do they work?
- (5) What don't we know yet?

### **Objectives of the Study:**

**This paper has five objectives.**

1. To identify and categorize the main barriers to IIoT adoption for manufacturing MSMEs in India.
2. To analyze how different categories of barriers interact with each other.
3. To document evidence of IIoT adoption outcomes from Indian MSMEs that have succeeded.
4. To review the current policy landscape.
5. To identify gaps in existing research that need attention.

## LITERATURE REVIEW

### Introduction to IOT

The Industrial Internet of Things (IIoT) refers to networks of sensors and connected devices that collect and exchange data in real time within industrial environments (Shah et al., 2024). For manufacturing MSMEs, IIoT can enable real-time production monitoring, predictive maintenance, quality control, and supply chain optimization. Think of it as giving your factory a nervous system. Machines can tell you when they are about to break. Production lines can flag quality issues instantly. You can track inventory without walking to the warehouse.

### THEORETICAL FRAMEWORKS

Several frameworks help us understand technology adoption in MSMEs. The Technology-Organization-Environment (TOE) framework, developed by Tornatzky and Fleischer, is widely used. It says that adoption decisions are shaped by three factors: technological context (what the technology can do), organizational context (firm resources and management support), and environmental context (industry conditions, competitive pressures, regulations) (Sivathanu, 2021). A 2024 study extended this framework by adding an "Individual" dimension - employee skills, attitudes, and readiness (Mukherjee et al., 2024). This addition matters for MSMEs because the owner-manager's personal attitude often determines whether adoption happens at all. The study surveyed Indian SMEs and found that eight out of twelve hypotheses were accepted. Interestingly, infrastructure and prior experience did not matter as much as expected. Even MSMEs with poor infrastructure could still adopt IIoT successfully if other conditions were right.

Another study from 2025 applied the TOE framework along with institutional theory to study IIoT adoption among 207 manufacturing SMEs in Pakistan (Mubeen, Qureshi, & Shaikh, 2025). Seven out of eight hypotheses were supported, confirming that the same barrier categories apply across South Asian contexts.

### RESEARCH METHODOLOGY

#### Review Approach

This paper uses a systematic literature review approach. Researcher searched academic databases including Scopus and Google Scholar, along with government and news websites, for publications from 2018 to 2025. The search terms used were: ("Industrial Internet of Things" OR "IIoT" OR "Industry 4.0") and ("MSME" OR "SME") and ("adoption" OR "barrier") and ("India").

#### Types of Sources Used

Researcher has used following sources for the study

- **Peer-reviewed journal articles:** Kumar et al. (2022), Mukherjee et al. (2024), Sivathanu (2021), Swamidas, Singh, and Kumar (2024)
- **Government reports and news coverage:** NITI Aayog (2025), Administrative Staff College of India (2025), Institute for Competitiveness (2025), Economic Times (2025), CNBC TV18 (2025), Deccan Herald (2025)
- **Industry publications:** NASSCOM Community (2024), India Smart Manufacturing Report (2024)

### FINDINGS

#### Overview of Literature

The literature tells a consistent story. Manufacturing MSMEs in India face multiple barriers when trying to adopt IIoT. Let me walk you through what I found.

A 2022 study identified ten specific challenges through literature review and expert opinions from Delhi NCR (Kumar et al., 2022). The researchers used the DEMATEL technique to categorize challenges into "cause" and "effect" groups. The top "effect group" challenges - meaning the ones that result from other problems - were security of data and reliability of technologies. The researchers suggested that blockchain technology could help address these concerns.

A 2024 study surveyed SMEs across India and proposed twelve hypotheses based on technological, organizational, environmental, and human perspectives (Mukherjee et al., 2024). Eight hypotheses were accepted. What surprised me was that infrastructure, organizational readiness, internal excellence, and prior experience were among the rejected hypotheses. This suggests that even MSMEs with poor infrastructure or limited prior experience can still adopt IIoT successfully if other conditions are right.

A third study focused specifically on auto-component manufacturing SMEs in India (Sivathanu, 2021). The researcher surveyed 320 firms and found that IIoT expertise, IIoT infrastructure, relative advantage, compatibility, cost, security, organizational readiness, top management support, competitive pressure, and support from technology vendors all affect adoption.

A conference paper from 2024 studied IoT adoption in MSMEs and identified several benefits including improved productivity, better customer response, and enhanced profitability (Swamidas et al., 2024). The paper also noted that IoT helps with remote monitoring and supply chain efficiency.

### Four Categories of Barriers

**Table 1: Categories of IIoT Adoption Barriers for Indian Manufacturing MSMEs**

Category	What It Means	Specific Barriers	Evidence
Technological	Problems with hardware and connectivity	Outdated machinery, poor internet, data security fears	Kumar et al. (2022) found security and reliability are top concerns
Organizational	Problems with people and skills	Lack of digital skills, low awareness, management not committed	Only 10% of MSMEs have used any government scheme (ASCI, 2025)
Financial	Problems with money	High upfront costs, credit gap, unclear returns	Only 19% of MSME credit demand is met (Institute for Competitiveness, 2025)
Environmental	Problems outside the factory	Weak vendors, policy gaps, unreliable power	No specific law for Industry 4.0 adoption (Taxmanagementindia, 2025)

### Technological Barriers

Let me start with the most obvious problem: old machines. The NITI Aayog-ASCI report says 60% of medium enterprises are running equipment that should have been replaced years ago (Administrative Staff College of India, 2025). These machines were built before the internet was even a thing. They do not have sensors. They cannot talk to anything. Retrofitting them is possible - one study did it for INR 1.3 lakh (Patil et al., 2025) - but most factory owners do not know this or do not have a person on staff who can figure it out. Security is another worry. The 2022 study found that data security and technology reliability were the top "effect group" challenges (Kumar et al., 2022). MSME owners worry about their production data being hacked. They are not sure if the technology will work consistently. These are legitimate concerns.

### Organizational Barriers

Digital skill shortages are perhaps the biggest problem. Most manufacturing MSMEs simply do not have employees who understand IoT, data analytics, or system integration. The ASCI report found that only 10% of medium enterprises have used any of the 18 schemes offered by the Ministry of MSME (Administrative Staff

College of India, 2025). This is not because the schemes are bad. It is because MSME owners do not know about them or find the application process too complicated.

The auto-component study found that top management support significantly affects adoption (Sivathanu, 2021). In plain English: if the owner is not committed, it will not happen. The 2024 study added that human factors - employee skills and attitudes - matter just as much as technology and money (Mukherjee et al., 2024).

### Financial Barriers

The financial numbers are staggering. A report by NITI Aayog and the Institute for Competitiveness (2025) estimates the credit gap for Indian MSMEs at ₹80 lakh crore. Only 19% of the total credit demand is currently being met. Let me put this in perspective. This is not just about IIoT adoption. This is about basic working capital. If an MSME cannot get a loan to buy raw materials or pay salaries, how can it invest in sensors and software?

The NITI Aayog-ASCI report recommends several financial solutions: a working capital financing scheme linked to enterprise turnover, a ₹5 crore credit card facility at market rates, and a "Fund of Funds" to help MSMEs access venture and private capital (NITI Aayog, 2025). These are good ideas, but they remain recommendations, not implemented policies.

### Environmental Barriers

Environmental barriers are about the ecosystem outside the factory. The technology vendor ecosystem for MSMEs is underdeveloped. Most IoT vendors focus on large enterprises because that is where the big money is. MSME-friendly solutions - affordable, easy to install, with good support - are rare (NASSCOM Community, 2024). Policy implementation gaps are another barrier. As one analysis notes, while India has many schemes, no specific legislative framework exists to directly facilitate Industry 4.0 adoption among MSMEs (Taxmanagementindia, 2025).

### Cumulative Effects of Barriers

Here is what makes this problem so tricky. The barriers do not sit in neat little boxes. They talk to each other. They make each other worse.

Imagine you own a factory with old machines (technological barrier). You need to spend money to add sensors (financial barrier). But money is tight. And you are not even sure if this IoT thing will actually help (organizational barrier). And even if you want to try, finding a good vendor who understands old machines is difficult (environmental barrier). One problem leads to another leads to another. The low scheme awareness problem shows another interaction. Even when financial support exists through government schemes, organizational barriers (low awareness, complex applications) prevent MSMEs from accessing it. So the money sits unused while MSMEs struggle. This is why giving subsidies alone will never work.

### Success Stories

Despite all these barriers, some Indian MSMEs have figured it out. Table 2 summarizes documented success stories.

**Table 2: Documented IIoT Success Stories in Indian Manufacturing MSMEs**

Sector	What They Did	What Happened	Source
Automotive parts	AI-driven predictive maintenance	20% less downtime, 15% lower maintenance costs	NASSCOM, 2024
Textile manufacturing	IoT sensors for real-time monitoring	25% improvement in efficiency	NASSCOM, 2024

Precision engineering	AI-driven quality control	35% fewer defects	NASSCOM, 2024
General manufacturing	Smart assembly cell	22.5% faster cycle time, 71% fewer errors	Patil et al., 2025
Logistics MSME	IoT for supply chain tracking	Better delivery speed and cost efficiency	Swamidas et al., 2024

All mentioned above have focused on one problem - predictive maintenance, or production monitoring, or quality control. They did not try to transform the entire factory at once. And where documented, they achieved payback within one year.

The smart assembly cell project by Patil, Patil, and Kulkarni (2025) is particularly worth highlighting. The total upgrade cost was just INR 129,988 - less than the salary of one engineer for a year. And the results were dramatic: 22.5% reduction in cycle time and 71.43% reduction in errors.

### The Policy Landscape

The government has not been inactive. Table 3 summarizes key policy initiatives and recommendations.

**Table 3: Summary of Policy Initiatives and Recommendations**

Initiative	What It Is	Status	Source
MSME Digitalization Scheme (2022)	Financial support for digital adoption	Existing	Ministry of MSME
India MSME Competence Centres	Converting Technology Centres to help MSMEs	Recommended	NITI Aayog, 2025
Dedicated R&D cell in MSME Ministry	Focus on technology development	Recommended	NITI Aayog, 2025
₹5 crore credit card facility	Working capital for medium enterprises	Recommended	NITI Aayog, 2025
Fund of Funds for MSMEs	Venture and private capital access	Recommended	NITI Aayog, 2025

The gap between policy and practice remains wide. Good recommendations exist. Good schemes exist. But awareness is low, implementation is patchy, and only 10% of MSMEs have used any scheme (Administrative Staff College of India, 2025).

News reports from May 2025 confirm that most medium enterprises still use outdated technology, and MSMEs need better tech infrastructure to compete (Deccan Herald, 2025; CNBC TV18, 2025).

The Economic Times (2025) reported that NITI Aayog has proposed tailored financial and technology tools for medium enterprises, including a ₹5 crore credit card and working capital financing linked to turnover. But these are still proposals, not implemented programs.

## DISCUSSIONS

**First, the barriers are multiple and interconnected.** You cannot fix just one and expect success. Giving subsidies while ignoring skill shortages or poor connectivity will fail. The 2024 study that added "human factors" to the analysis was right - people matter as much as technology (Mukherjee et al., 2024).

**Second, the gap between policy and practice is striking.** Only 10% of MSMEs have used any government scheme (Administrative Staff College of India, 2025). The recommendations from NITI Aayog are good, but they are not yet implemented. News reports confirm that most medium enterprises still use outdated technology (Deccan Herald, 2025).

**Third, financial barriers are severe but not the whole story.** The credit gap of ₹80 lakh crore is enormous (Institute for Competitiveness, 2025). But even when schemes exist, MSMEs do not use them because of low awareness and complex applications.

**Fourth, success is possible and affordable.** Patil et al. (2025) showed IIoT adoption for INR 1.3 lakh with significant improvements. The NASSCOM examples show payback within one year. The logistics MSME in the conference paper saw real benefits (Swamidas et al., 2024).

**Fifth, organizational factors matter as much as money.** The auto-component study found that top management support significantly affects adoption (Sivathanu, 2021). The 2024 study found that human factors were critical (Mukherjee et al., 2024). If the owner is not committed, nothing else matters.

### Research Gaps

Despite growing research, several gaps remain. Table 4 summarizes them.

**Table 4: Research Gaps Identified**

Gap	What Is Missing	Why It Matters
Sector-specific studies	Most studies treat all manufacturing the same	Auto-components, textiles, and food processing have different needs
Policy evaluation	No systematic check of whether schemes work	We do not know what actually helps MSMEs
Longitudinal research	All studies are snapshots	We do not know how adoption happens over time
Regional studies	Most studies from Delhi NCR, Pune, Bengaluru	Other industrial areas may face different barriers

The Kumar et al. (2022) study used experts only from Delhi NCR. Can we generalize those findings to Tamil Nadu or Gujarat or West Bengal? Probably not. We need more regional research.

### Future Research Directions

**For MSME owners:** Start small. The evidence is clear that low-cost pilots work. Patil et al. (2025) spent INR 1.3 lakh and got results within months. The NASSCOM examples show payback within one year. Pick one problem - downtime, quality, efficiency - and solve it with a small IIoT project. Do not wait for perfect conditions.

**For policymakers:** Stop creating new schemes. Fix the existing ones. Only 10% of MSMEs have used any scheme (Administrative Staff College of India, 2025). This is not a scheme problem. It is an awareness and simplicity problem. Also, implement the NITI Aayog recommendations for Competence Centres and R&D cells (NITI Aayog, 2025).

**For industry associations:** Bridge the gaps that individual MSMEs cannot cross alone. Create simple, local training programs. Help MSMEs find good vendors. The NASSCOM success stories show what is possible (NASSCOM Community, 2024). Now scale it up.

**For technology vendors:** Build MSME-friendly solutions. Low-cost, easy to install, with good support. The market is huge - 0.3% medium enterprises contribute 40% of MSME exports (Administrative Staff College of India, 2025). These are serious businesses with money to spend if you offer the right product.

## CONCLUSION

### Summary

This review examined available literature on IIoT adoption barriers for manufacturing MSMEs in India. Five main findings stand out.

First, barriers fall into four categories - technological, organizational, financial, and environmental - and these categories interact. You cannot fix just one.

Second, current adoption rates remain very low despite a decade of government promotion. The NITI Aayog-ASCI report found that 82% of medium enterprises do not use Industry 4.0 technologies (Administrative Staff College of India, 2025).

Third, the financial credit gap is enormous at ₹80 lakh crore, with only 19% of MSME credit demand being met (Institute for Competitiveness, 2025). But financial barriers alone do not explain low adoption.

Fourth, successful adoption is possible and affordable. Patil et al. (2025) demonstrated IIoT implementation for INR 1.3 lakh with significant operational improvements. The NASSCOM examples show payback within 9-12 months.

Fifth, significant research gaps remain. We need sector-specific studies, policy evaluations, longitudinal research, and regional studies.

The problem is a combination of low awareness, skill shortages, complex schemes, underdeveloped vendor ecosystems, and policy implementation gaps. These barriers interact and amplify each other.

The way forward requires coordinated effort from MSMEs, policymakers, industry associations, and technology vendors. No single actor can solve this alone. But with strategic support in finance, technology, infrastructure, and skilling, Indian manufacturing MSMEs can transition toward smart manufacturing.

### Limitations of the Study

**Geographic scope.** The evidence base is stronger for certain regions like Delhi NCR and Pune. Findings may not represent all of India.

**Sectoral coverage.** The evidence is stronger for auto-components than for textiles, food processing, or pharmaceuticals.

**Publication bias.** This review draws from published literature and news reports. Unpublished studies or failed implementations may be underrepresented.

**Rapid technological change.** IIoT technology is evolving quickly. Some findings may date rapidly.

**Source availability.** Researcher have used only sources that are publicly available. Some relevant government documents may not be accessible.

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