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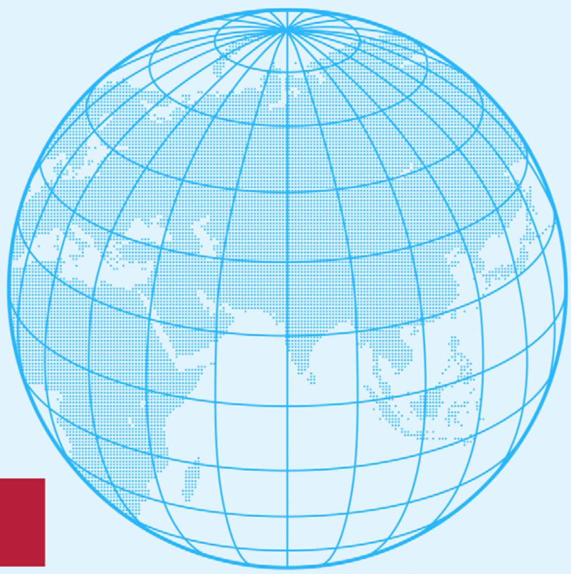
Wheels of Change

Automation in India's Automotive Sector

Vandana Vasudevan



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Wheels of Change

Automation in India's Automotive Sector

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Abbreviations

ACMA	Automotive Component Manufacturers Association
AI	Artificial Intelligence
AR	Augmented Reality
ASI	Annual Survey of Industries
CAGR	Compound Annual Growth Rate
CEO	Chief Executive Officer
CNC	Computer Numerical Control
CTO	Chief Technology Officer
CTS	Craftsmen Training Scheme
DGT	Directorate General of Training
ESI	Employees' State Insurance
EV	Electric Vehicle
FDI	Foreign Direct Investment
FTE	Fixed-term Employment
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
IBEF	India Brand Equity Foundation
ICE	Internal Combustion Engine
IFR	International Federation of Robotics
IoT	Internet of Things
ITI	Industrial Training Institute
ITRI	Industrial Technology Research Institute
JIIM	Japanese India Institute for Manufacturing
JV	Joint Venture
KA	King Auto Parts
MSDE	Ministry of Skill Development and Entrepreneurship
MSME	Micro, Small, and Medium Enterprise
NCR	National Capital Region
NCVET	National Council for Vocational Education and Training
NH	National Highway
NSSO	National Sample Survey Office
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PF	Provident Fund
PLFS	Periodic Labour Force Survey
PP	Precision Production
PwC	PricewaterhouseCoopers
R&D	Research and Development
RFID	Radio Frequency Identification
RQ	Research Question
SIAM	Society of Indian Automobile Manufacturers
SME	Small and Medium Enterprise
SOP	Standard Operating Procedure
SS	Silver Star
VR	Virtual Reality

Executive Summary

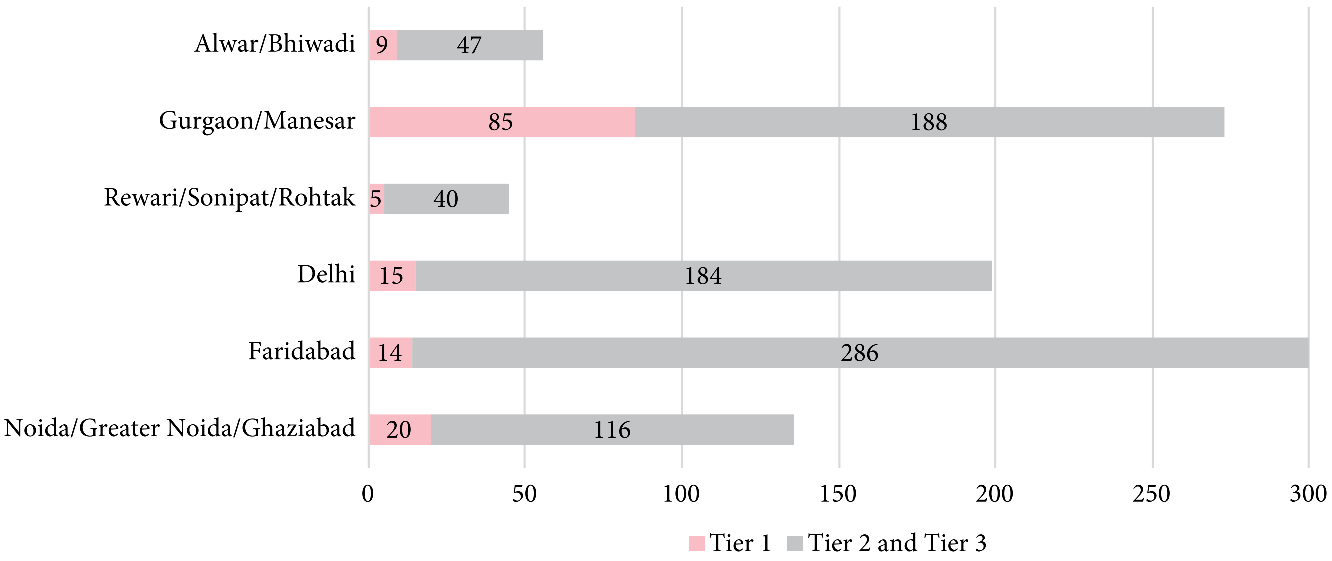
India's automotive industry contributes about 7% to the national gross domestic product (GDP) and employs roughly 32 million people directly and indirectly (NITI Aayog, 2025). India's experience is analogous to the historical experiences of industrialising nations, such as the US, Japan, and Germany, where the automotive industry has long been a central engine of growth.

Supporting this growth, the auto-component industry has become a vital segment of the economy, spanning large corporations to micro-enterprises across manufacturing clusters nationwide. It accounted for 2.3% of India's GDP in FY2025, employed 1.5 million people, and grew roughly at 14% annually between FY2020–2025 (India Brand Equity Foundation [IBEF], n.d.).

India's northern cluster of the automotive industry accounts for roughly half of the country's four-wheeler production. This cluster lies along NH48, extending from Haryana (Gurugram, Manesar, Rewari, and Bawal) to Rajasthan (Bhiwadi and Alwar). Haryana's early role in hosting the Maruti–Suzuki and Hero–Honda joint ventures (JVs) in the 1980s resulted in the growth of a dynamic auto component industry in the region. However, data from the Automotive Component Manufacturers Association [ACMA], Society of Indian Automobile Manufacturers [SIAM], and MarkLines analysed for this study show that around 80% of auto-component firms in the Delhi–Haryana cluster are Tier-2 and Tier-3 Micro, Small, and Medium Enterprises (MSMEs), while only about 20% are large Tier-1 manufacturers with deep linkages to global supply chains.

Globally, the automotive industry has been at the forefront of Industry 4.0 adoption—integrating robotics, Internet of Things (IoT) systems, advanced sensors, automated quality checks, and data-driven maintenance into production processes. India, though a subsequent entrant, now ranks among the top 10 robot-installing countries (International Federation of Robotics [IFR], 2023), with the automotive sector accounting for around 40% of all industrial robot installations in the country.

Figure ES–1: Distribution of Auto-component Manufacturers in Delhi National Capital Region



Source: Author's compilation based on the 2019 data from the Automotive Component Manufacturers Association and MarkLines.

Objective and Scope of the Study

This study examines how automation is unfolding in India's auto-component manufacturing and what it means for firms and workers. The focus is not on the Original Equipment Manufacturers (OEMs)—whose automation strategies are well-documented—but on the heterogeneous base of Tier-1, Tier-2, and Tier-3 component manufacturing companies.

Primary research was conducted in three auto-component factories in the Gurugram–Manesar cluster, each of which was treated as a case study.

- A large Tier-1 manufacturer with a global presence;
- A medium-sized MSME supplying to domestic OEMs;
- A small MSME using a specialised technology.

These firms differ significantly in size, capital intensity, product characteristics, labour composition, and market orientation. Observations from the shop floor and discussions with management and union leaders form the empirical basis for this analysis. These insights were supplemented with data from industry groups like ACMA, SIAM, the Annual Survey of Industries (ASI), and international studies. By providing evidence from the shop floor, this study contributes to the broader debates about technological change in emerging economies.

The study was guided by two questions:

- How is automation taking place in auto-component firms, and what factors influence automation decisions?
- What are the implications of these automation patterns for workers, skill requirements, and the broader trajectory of the industry?

Key Findings

Automation is the fastest among Tier-1 suppliers

Automation is occurring most rapidly among Tier-1 suppliers that handle high volumes and operate under strict quality standards set by international OEMs. These firms have invested in robots for welding, forging, material handling, and automated inspection. Their rationale for adopting automation is not just to replace labour but to achieve quality consistency, traceability, safety, and cycle-time reduction. In these companies, automation is part of a long-term commitment to precision manufacturing and export competitiveness.

Micro, Small, and Medium Enterprises automate selectively and reactively

For MSMEs, automation is less about competing and more about coping with local constraints such as labour volatility, absenteeism during festive times, and the difficulty of finding workers who can adapt to higher-quality or time-sensitive production. Managers emphasised that robots "do not fall sick, do not take leave, and do not vary in their output," all of which are critical for meeting OEM schedules. Their introduction of robots or semi-automated systems is aimed at resolving bottlenecks: repetitive tasks causing strain, high temperatures, or high levels of precision that are unsustainable for workers.

Small firms face structural barriers to automation

Small firms face several structural barriers, even though they are enthusiastic about automation in principle. The specialist firm examined in this study produces hundreds of items and receives small monthly orders, often in batches of 5,000–10,000 units. Automation set-up times, limited shop-floor space, and the lack of economies of scale make investments in robots unviable. Even when owners wish to automate, they simply cannot justify the capital expenditure. These firms typically struggle with productivity, limited working capital, outdated modes of production, and a shortage of trained technicians.

Labour regimes shape automation decisions

There is continued dominance of contract labour across the auto-component industry. Contract labourers are recruited through a manpower agency and can be retrenched by the company anytime, for example, if there is a lean season in production, thus giving firms flexibility; however, this also introduces instability in production. Owners noted that contractual workers have weaker attachment to the workplace and greater absenteeism—factors that directly influence a firm's push towards automation. In contrast, where firms employ permanent workers in specialised roles, the preference is to retain them due to high training costs. These workers could move from being operators to supervisors with the oversight of one or two workers. In a larger MSME, they would oversee a line of production or become a trainer who could train other workers on operating industrial robots.

India's new draft Labour Codes of 2025, which formally introduce fixed-term employment (FTE) as a recognised category, aim to promote direct hiring and help reduce excessive contractualisation. Fixed-term employees are entitled to the same statutory benefits as permanent employees. Whether FTE becomes significant in industrial settings, replaces contractual labour, and how it interacts with automation and skill formation remains to be seen.

Automation has not yet led to significant job losses in the three firms studied

None of the three firms had retrenched workers, though the reasons for not doing so were different in each case. In the large Tier-1 company and the medium-sized one, as business was booming, workers whose jobs were now being done by robots were redeployed to other roles, such as inspection, maintenance, and supervision. In the case of the small manufacturer, workers had been trained in a niche technology, and hence it was too costly to retrench them.

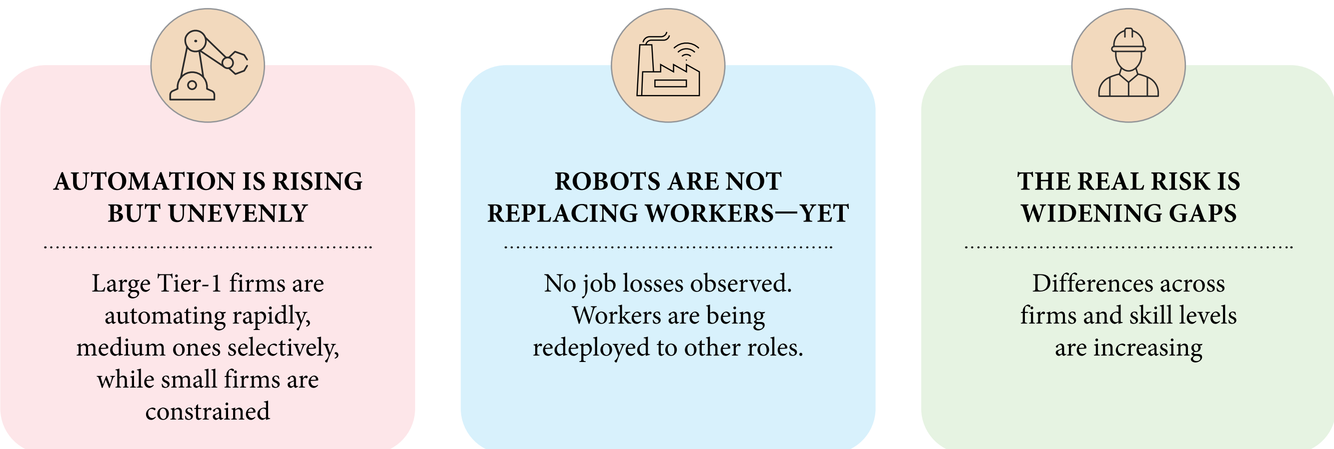
Workers expressed no fear of losing jobs to robots. In fact, union leaders described automation as inevitable and beneficial. They viewed robots as improving safety, reducing drudgery, and enhancing production quality. This echoes international evidence suggesting that while robots may displace certain repetitive tasks, they do not necessarily eliminate employment in aggregate. Indian data also point in that direction, as ASI data show that among the workers in the manufacturing sector, the percentage of total workers employed by the automobile industry in fact increased from 6% in 2012–2013 to 7% in 2022–2023.

Implications of Uneven Automation

The uneven adoption of automation, as evidenced in this study, may result in three kinds of gaps:

- ***Skill gap:*** The shop floor of an automated or semi-automated plant demands abilities that differ from those in manual settings: monitoring machine dashboards, understanding cycle-time logic, troubleshooting, and collaborating with automated systems. These are not necessarily "higher" skills, but they are different skills. Workers who acquire them can command higher wages and more stable employment. Those who cannot become increasingly marginalised. International scholarship—from Acemoglu and Restrepo to McKinsey Global Institute—warns that the next generation of automation, integrating artificial intelligence (AI)-driven quality control, predictive maintenance, and collaborative robots, will widen the skill gap further.
- ***Intra-industry gap:*** The significantly slower pace of automation in smaller component manufacturers threatens to widen the gulf between Tier-1 firms and MSMEs, which form the majority of the component industry in the National Capital Region (NCR). This has direct implications for the future readiness of small firms in the region and can result in Tier-1 component makers cornering a massive competitive advantage.
- ***Regional gap:*** This uneven progression of automation can create regional imbalances within India's auto industry. Regions with a concentration of Tier-1 firms—such as Pune or Chennai—may accelerate technologically, while clusters dominated by MSMEs—like the Delhi–Haryana belt—risk stagnation unless supported by targeted policy interventions.

Figure ES–2: Snapshot of Key Findings



Source: Author's analysis.

Policy Recommendations

- Firstly, there is a need to strengthen the training ecosystem. Industrial Training Institutes (ITIs) and polytechnics currently lag behind the needs of automated manufacturing. The Dattopant Thengadi National Board for Workers Education and Development (formerly the Central Board for Workers Education), which runs programmes to bridge the domain and employability skill gap, has to factor in the rapid adoption of robots in industries like automotive.
- Secondly, MSMEs need support to adopt automation through subsidised credit, shared automation centres where pilot projects can be tried out, and cluster-based technology facilities that reduce the burden of capital expenditure.
- Thirdly, policymaking must anticipate that not all displaced or under-skilled workers will be able to transition into robot-assisted roles. Public policy must consider pathways for 'decent work' as defined by the International Labour Organisation, for those outside the ambit of skilling, to avoid polarisation of workers.

Conclusion

Automation in India's auto-component industry is not happening at a uniform scale and pace, and is shaped by firm size, labour markets, and structural constraints. Workers do not presently feel threatened and, in many cases, welcome automation. However, the shop floor in automotive manufacturing will inevitably change due to technology creating gaps in skilling as well as competitiveness of firms within the northern auto corridor and also across regions. The long-term trajectory will depend on how policy prepares workers and firms for this phase of industrial change.

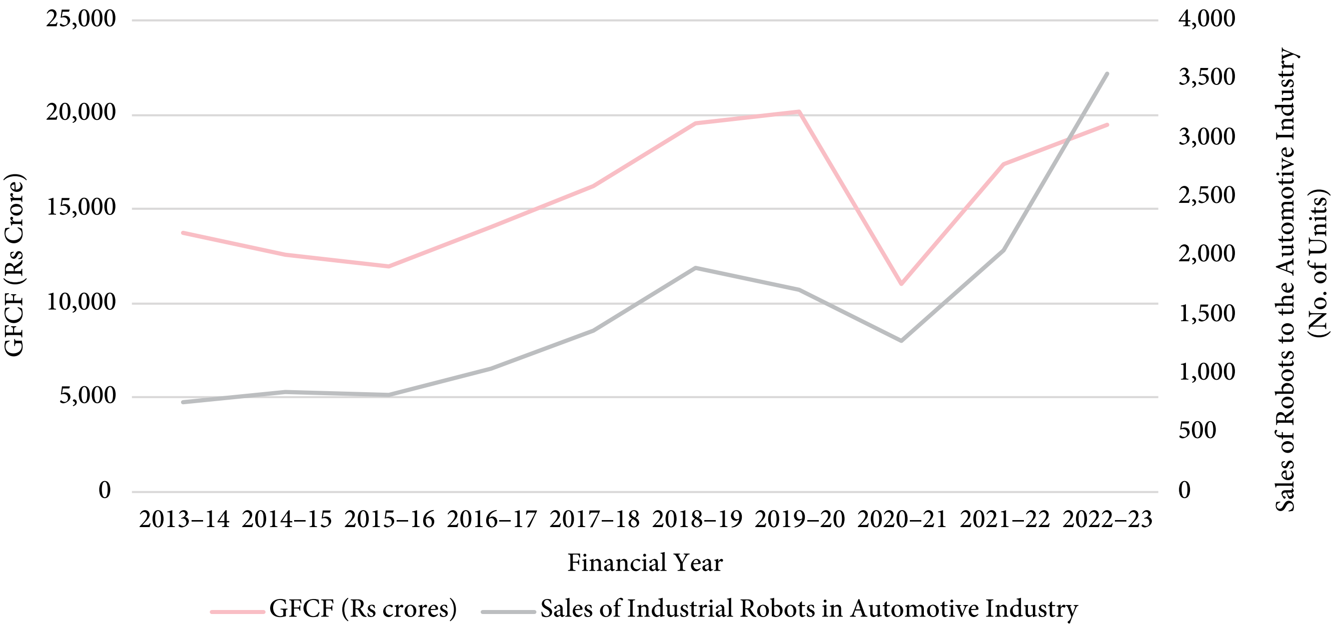
1. Introduction

Industry 4.0 or the fourth Industrial Revolution, characterised by the digital transformation of manufacturing and industrial processes, is bringing about a sweeping change on the shop floors of manufacturing industries. Automation in the form of industrial robots is being increasingly deployed to do the work that humans have been doing ever since the dawn of factory production. Industrial robots are programmable and autonomous machines capable of executing complex operations. These robots are massive, inflexible, and usually installed to perform dangerous and physically demanding tasks that may be hazardous for humans, such as transporting heavy loads in factories (Patil et al., 2023). In various forms, automation is expected to affect production activities globally. However, over two-thirds of the workers expected to be impacted belong to four countries—China, Japan, India, and the US.

In India's manufacturing sector, around 67% of the work has the potential to be automated, with industrial robots replacing human labour, which equates to around 44.5 million jobs (Manyika et al., 2017). According to the IFR, China had 276,288 industrial robots installed in 2023, representing 51% of global installations. India ranks seventh in the list of countries that installed the maximum number of industrial robots (IFR, 2023). India's robot installations increased by 59% from the previous year to 8,510 units in 2023, a new high. Demand from the automotive industry soared to 3,551 units—an increase of 139%.

Figure 1 plots Gross Fixed Capital Formation (GFCF) in the Indian automotive and auto-component industry alongside an estimate of annual industrial robot installations attributable to the sector. The automotive industry remains India's largest adopter of industrial robots, accounting for roughly 40% of all installations in 2023 (IFR, n.d.). Although the IFR does not publish year-wise robot sales specifically for the auto-component segment, applying this sectoral share to India's total annual robot installations provides a reasonable approximation of the sector's trajectory.

Figure 1: Gross Fixed Capital Formation and Robot Sales in the Automotive Industry



Sources: Annual Survey of Industries: Gross Fixed Capital Formation;
International Federation of Robotics: estimated sales of robots in the automotive industry.
Note: GFCF = Gross Fixed Capital Formation.

Both GFCF and estimated robot installations follow a similar pattern: steady growth through 2019–2020, a sharp contraction during the pandemic, and a pronounced post-pandemic rebound. The steep rise in robot adoption after 2021–2022 suggests that automation has become a more prominent component of capital expenditure as firms seek greater operational resilience and reduced dependence on manual labour.

The Indian automobile industry is a significant driver of economic growth; in FY 2024, the sector recorded automobile domestic sales growth of 12.5% (Hindu Business Line, 2024). According to NITI Aayog (2025), the automotive industry contributes 7% to India's GDP and 49% to manufacturing GDP, and automobile exports comprise 4.7% of India's total exports in value. The auto industry has been growing rapidly post-liberalisation in the early 1990s, as the graph in Figure 2 shows.

This growth in business has been able to absorb more workers despite the trend towards automation, as seen in the growth in the number of workers in the automobile industry. ASI data show that between 2012–2013 and 2022–2023, among all manufacturing workers, the percentage of workers employed in the automobile industry grew from 6% to 7%.

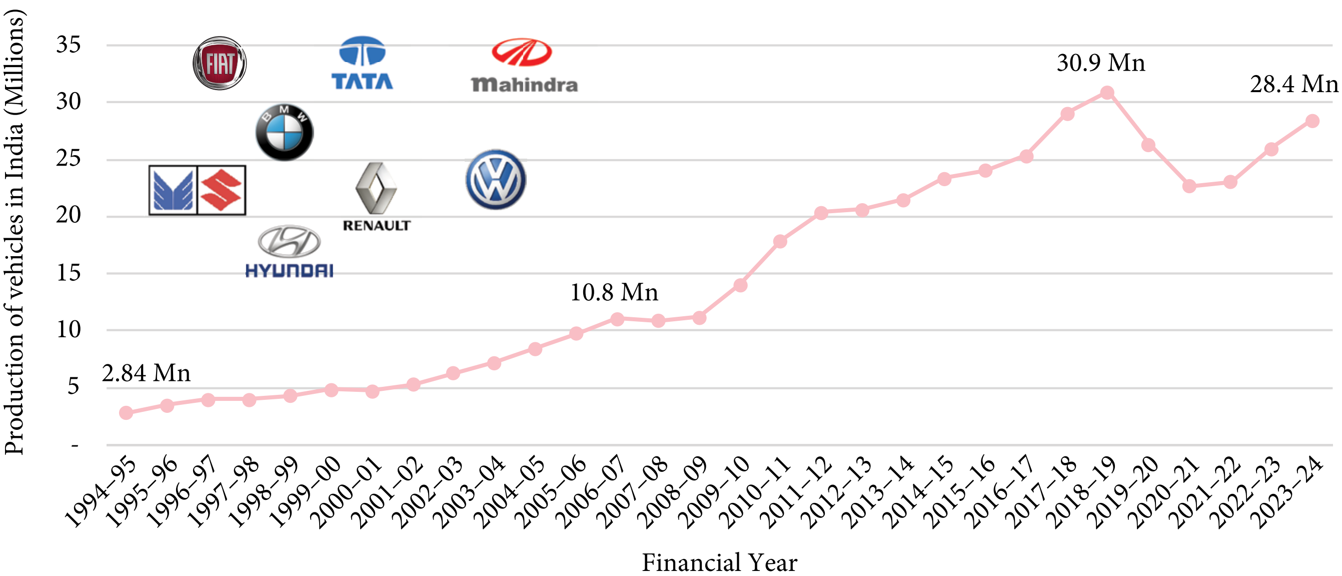
The northern corridor from Gurugram and Manesar in Haryana, up to Alwar in Rajasthan, along NH 48, is the oldest cluster and is called the "Auto Hub" of the country. It accounts for 50% of four-wheelers manufactured in India, according to some estimates (Financial Express, 2022). The northern cluster is dominated by three OEMs, namely Maruti–Suzuki, Hero MotoCorp, and Honda. Fuelled by the growth of the automotive industry, the auto-component industry has also experienced high growth.

The Indian auto-component industry recorded a turnover of ₹6,73,000 crore (US$78.74 billion) in FY 2025, registering a Compound Annual Growth Rate (CAGR) of 14% between FY 2020–2025. India is growing into a global destination for auto-component sourcing, with the industry exporting more than 25% of its production every year (IBEF, n.d.).

It accounted for 2.3% of India's GDP in FY 2025 and provided direct employment to over 1.5 million people, a figure expected to rise as the sector's GDP contribution reaches 5–7% by 2026 (IBEF, n.d.).

The remainder of the paper is organised as follows. Section 2 outlines the research questions (RQs). Section 3 reviews the literature on automation and labour in industrial settings, and Section 4 describes the methodology used. Section 5 presents the findings from three auto-component firms of different sizes in the Gurugram–Manesar cluster, drawing on plant observations, discussions with management, and interactions with union leaders. Section 6 interprets these findings in relation to the broader structure of the auto-component industry; it explores the role of labour markets in shaping each firm's automation strategy and considers the policy implications of these emerging patterns. Section 7 concludes by summarising how the findings answer the RQs.

Figure 2: Growth of the Indian Automobile Industry Over Time



Source: Society of Indian Automobile Manufacturers.

2. Research Questions

We ask the following questions in the context of India's auto-component industry:

RQ1. What factors influence the adoption of automation?

RQ2. What are the likely implications of the pattern of automation that is taking place in this industry?

3. Literature Review

3.1 Will Robots Replace Human Labour?

Research over the past decade has produced mixed views on whether automation will lead to large-scale job loss. Early studies took a strongly alarmist view. Frey and Osborne (2013) estimated that 47% of US jobs were at high risk due to automation, while Brynjolfsson and McAfee (2014) argued that digital technologies could permanently shrink the share of employed workers even as productivity rises. Furthermore, the World Bank (2016) suggested that more than half of the jobs in Organisation for Economic Co-operation and Development (OECD) countries were vulnerable.

However, this wave of pessimism was quickly questioned. Arntz et al. (2016) argued that most occupations consist of many different tasks, only some of which are easily automated, and revised the OECD estimate down to about 9%. Bessen's historical analysis (2019) of the textiles, steel, and automotive sectors showed that automation often coincided with decades of strong employment growth before stabilising. Evidence from China and South Korea similarly suggests that robots do not simply replace labour but can be integrated into production in ways that support employment (Focacci, 2021).

Acemoglu and Restrepo (2017) documented that robots reduced employment and wages in some US regions between 1990 and 2007, but even under aggressive assumptions, only a small share of total jobs would be affected. Their later work (2018) showed that automation substitutes for some tasks but also creates new ones in which humans retain an advantage, keeping overall employment stable in the long run.

Other studies examining factory-level robot adoption show a similar pattern. De Vries et al. (2020) found that although routine manual jobs declined, automation did not lead to broad labour displacement in advanced economies. Mani (2017) estimated that robots had replaced only about 10 jobs per 10,000 workers in Indian manufacturing, particularly in the automobile sector.

Overall, the literature suggests that the early fears of mass job elimination have moderated. Automation does affect specific tasks and occupations, but its net impact on employment is smaller and more complex than initially predicted. However, even if automation does not wipe out jobs in aggregate, its effects vary sharply by industry structure and nature of the task—a distinction particularly relevant to India's auto-component sector.

3.2 Varying Impact Across Industries and Occupations

While automation may not lead to widespread unemployment, there is broad agreement that its effects vary sharply across industries and occupations. Sectors such as transportation, storage, and manufacturing have some of the highest shares of jobs that can be automated—estimated at 52% and 45%, respectively, by the 2030s—with machine operators and assemblers among the most exposed roles (PricewaterhouseCoopers [PwC], 2017).

The World Economic Forum's Future of Jobs 2023 report, based on a survey of more than 800 major employers, paints a mixed picture. Of the 28 technologies considered, only humanoid and non-humanoid robots were expected to have a net negative effect on jobs. Most digital and platform technologies were expected to generate more jobs than they displaced, even if transitions would be disruptive.

A separate stream of literature focuses on human–robot interaction and the practical limits of automation. Although robots reduce errors, they are not immune to failures. Studies note problems such as sensor malfunction, misalignment, gripping errors, and dropped parts (Morales, 2018; Zore et al., 2021). Robots are also vulnerable to hazards like electrical issues, unexpected movements, wear and tear, and environmental conditions such as welding fumes or heat (Occupational Safety and Health Administration [OSHA], n.d.).

For these reasons, several authors emphasise that humans remain indispensable in automated environments. Human supervisors respond to irregular situations, handle complexity, and detect subtle defects that machines may miss (Bernier, 2023; Murashov et al., 2016). Rather than full replacement, the literature points to a reorganisation of tasks where humans and robots complement each other in different ways.

Taken together, the literature suggests three broad conclusions. First, large-scale technological unemployment is unlikely in the short to medium term, as automation tends to substitute specific tasks rather than entire occupations. Second, the impact of automation varies considerably across industries, regions, and skill groups, with routine manual jobs facing greater exposure. Third, even in highly automated environments, human oversight remains necessary due to the technical and operational limits of robotic systems. However, much of this scholarship is based on advanced economies and macro-level data. There is limited empirical evidence from developing-country manufacturing clusters, particularly from firm-level and shop-floor observations that examine how automation decisions are shaped by scale, labour regimes, and structural industry characteristics. This study addresses that gap by providing comparative evidence from three auto-component firms in India's largest automotive cluster.

4. Methodology

This paper uses comparative plant-level observation and interviews from three auto-component firms to document how automation is being implemented on the shop floor and to analyse its immediate consequences for labour and skills in the auto sector.

The paper uses the following approach. Secondary research was completed between May 2024 and July 2024. It included previous studies conducted in India and other countries on automation in the manufacturing sector, particularly in the automotive industry. The latest reports from the ASI, Economic Survey of India, and Periodic Labour Force Survey (PLFS), as well as reports from auto industry bodies such as ACMA and SIAM, were studied. The website MarkLines, which collates auto industry data from around the world, was an essential source of information.

The authors then visited four auto-component manufacturing facilities of three companies in Gurugram–Manesar between August 2024 and January 2025 to study their production lines. In total, 12 people were interviewed. Interviews with company management were in small group settings within the plant premises. Conversations with union leaders were on a one-to-one basis in neutral spaces. A discussion guide (enclosed in Appendix 3) was followed to help steer the conversations.

All company names and names of the people interviewed have been anonymised. These companies were deliberately selected for their varying sizes—a global exporter, a medium-sized manufacturer, and a small manufacturer. Table 1 presents the profile of the companies and people interviewed.

Table 1: Profile of the Companies Studied

Name and Profile of Company	Names/Designations of People Interviewed
SS A leading automotive technology company	CTO CEO Plant Head, Gurugram Plant Plant Head, Manesar Plant
KA Medium enterprise	Founder: R.K. Gupta, Age: 64 CEO (son of Founder): Amit Gupta, Age: 40
PP Small enterprise	Founding brothers: Sandeep Singh, Age: 51 Randeep Singh, Age: 47 Vivaan Singh (son of Sandeep Singh), Age: 24
Union Leaders	Rakesh Sharma: Union leader, major OEM in Gurugram–Manesar. Prakash Bhatti: Union leader of a large Japanese auto-component manufacturer (Tier-1 company). Surajmal: Office bearer in the union of a large Japanese auto-component manufacturer (Tier-1 company).

Source: Author's own compilation.

Note: SS = Silver Star; KA = King Auto Parts; PP = Precision Production; CEO = chief executive officer; CTO = chief technical officer; OEM = original equipment manufacturer.

5. Findings

The three companies were found to be at vastly different stages in their automation journey, which illustrates that the feasibility of automation is scale-dependent. The Tier-1 company, with predictable order volumes and global networks, was highly driven by automation to meet quality standards in export markets. The medium enterprise was motivated, among other factors, to automate to protect itself against the uncertainty of labour supply. The small enterprises, working with complex, low-volume, specialised processes and constrained by land and capital, however, may never reach the thresholds that justify robotisation, even if the owners are pro-automation.

Thus, automation in the Indian auto-component industry is uneven, and the automation strategy depends on the scale and size of the firm as well as on labour volatility, skill mismatch, and disciplinary issues with workers. Table 2 encapsulates the key findings from the primary research.

Table 2: Key Findings from the Primary Research

Size and Scale	Nature of Products and Market Share	Type of Processes	Engagement with Labour	Motivation to Automate	Level of Automation and Implications
SS Global presence. Tier-1. Publicly listed company of ₹1,000 + crores. 4,000 + employees. Several plants and warehouses across the globe.	Various auto-components, especially bevel gears, for all vehicles. Dominant in the domestic market—60% of passenger vehicles and 90% commercial vehicles; 8% share of the global bevel gear market.	Forging heat treatment.	Few permanent; rest contract. Challenges with finding skilled labour.	**High** Historically entered JVs with foreign companies to access new technology. To meet the quality standards of foreign OEMs.	**Almost fully automated** Able to achieve higher accuracy, consistency, and safety. Despite continuous automation, labour has been redeployed, not retrenched, as business has been growing.
KA A ₹60 crore SME. Family-owned and run business. 250 employees. Plants in Manesar and Kancheepuram.	Plastic components for auto and home appliances. Supplying to top OEMs.	Injection moulding.	Post-pandemic issues with absenteeism of migrant labour.	**High** Accelerated post-pandemic to reduce dependency on labour. Encouraging workers to upskill.	**Semi-automated** Experiencing higher accuracy, greater productivity, and safety in automated processes. On a steady march towards more automation.
PP A ₹20 crore SME. Family-owned and run business. 70 employees. Plant in Manesar.	Metal parts mainly for vehicles. Among the few players using sintered technology. Only one in Gurugram–Manesar.	Specialised technology using powdered metal-sintering.	All employees permanent; trained on the specialised production process.	**High** Discipline issues and the inconsistent work ethic of labourers are key motivators to replace them with robots.	**Manual** Unable to automate because of low economies of scale and constraints of capital and land.

Source: Author's own compilation.

Note: SS = Silver Star; KA = King Auto Parts; PP = Precision Production; OEM = original equipment manufacturer; SME = small and medium enterprise.

5.1 Inside the Shop Floor

Silver Star—Fully Automated Production

The plant in Gurugram produces bevel gears. Gears are made through forging and then dyeing. Forging is one of the oldest working techniques of humankind, where metal is heated and shaped into the required design. Two forging processes were observed at the Gurugram plant. Figure 3 illustrates the steps of the forging process, demarcating the human and robot phases.

Labour is involved only in the first phase of loading metal blocks onto the assembly line and at the end to check rejected components, as robots can err on the side of caution; some pieces rejected by the robot may, upon visual examination by a human, be deemed acceptable.

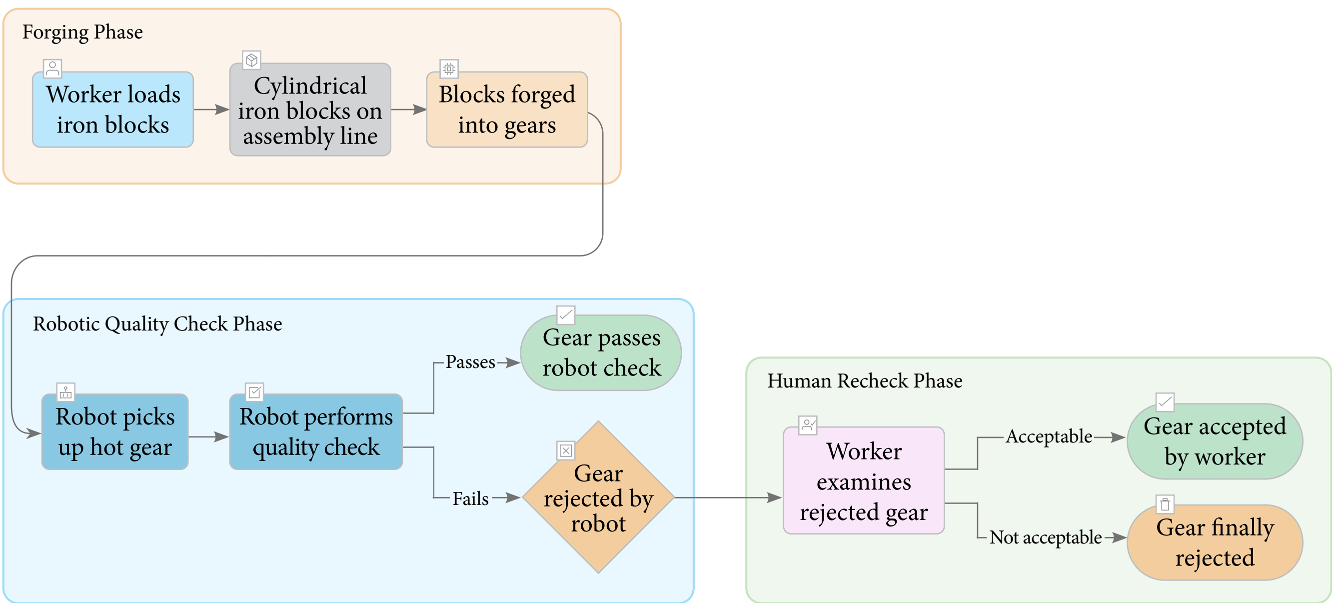
SS's Manesar Plant makes other products such as differential assemblies (the Gurugram Plant produces only bevel gears). Although it is less automated and has more employees than the Gurugram factory, the automation is more sophisticated. Deep learning techniques are employed to programme robots. In one process, a robot picks up a part called a Final Drive Gear and inspects it for precision and quality. If it detects a problem, it can trace the error to the exact sub-process on the assembly line that resulted in the deviation. A human supervisor then acts on the data provided by the robot and visually inspects the part. Every product has a Radio Frequency Identification (RFID) code, which allows its time and date of production to be traced. Fire safety training uses Augmented Reality (AR) and Virtual Reality (VR). The plant has moved from manual calculation of the number of items produced daily to smart production monitoring.

King Auto Parts: Semi-Automated Production

The facility in Manesar is a three-storey, 30,000-square-foot building with four assembly lines of 50 metres each, manufacturing 1,200–1,600 parts daily. The company produces plastic auto components, such as fan assembly, fan blower, air duct assembly, and handle grip cover. These are made using injection moulding machines or blow moulding machines. Injection moulding is a manufacturing process in which the molten material (in this case, plastic) is fed into a heated barrel and injected into a mould cavity, where it cools and hardens to the shape of the cavity.

The plant now has 30 robots imported from China and Germany attached to its injection moulding machines. A robotic arm enters the mould area and removes the freshly moulded part because it is still warm and prone to damage if dropped, making it difficult for a human to remove it consistently. The robot also transfers the finished part ejected by the machine to a cooling rack.

Figure 3: Forging Process Involving Both Robots and Workers in Silver Star



Source: AI-generated using Eraser based on prompts given by the author.

The company is steadily moving towards automation. It has invested in various precision measuring machines for quality control of the parts produced, testing equipment, and a Computer Numerical Control (CNC) Machining Centre, which is a computer-controlled machine tool that creates complex moulds and fixtures with high accuracy. Several manual activities have been slated for automation. For example, in one process, a person wrote the dates on finished parts, which were ejected at a rate of two parts every 50 seconds. This task was scheduled to be automated by fitting a printer into the machine to imprint the date on the component.

Precision Production: Fully Manual Processes

PP is the only auto-component manufacturing company in Gurugram–Manesar that works on sintering technology. Sintering is the process of pressing powdered metal into a mould and heating it to a temperature below its melting point, so that the particles bind together to form a solid object in the shape of the mould. This process helps them use less metal in production and generate no scrap.

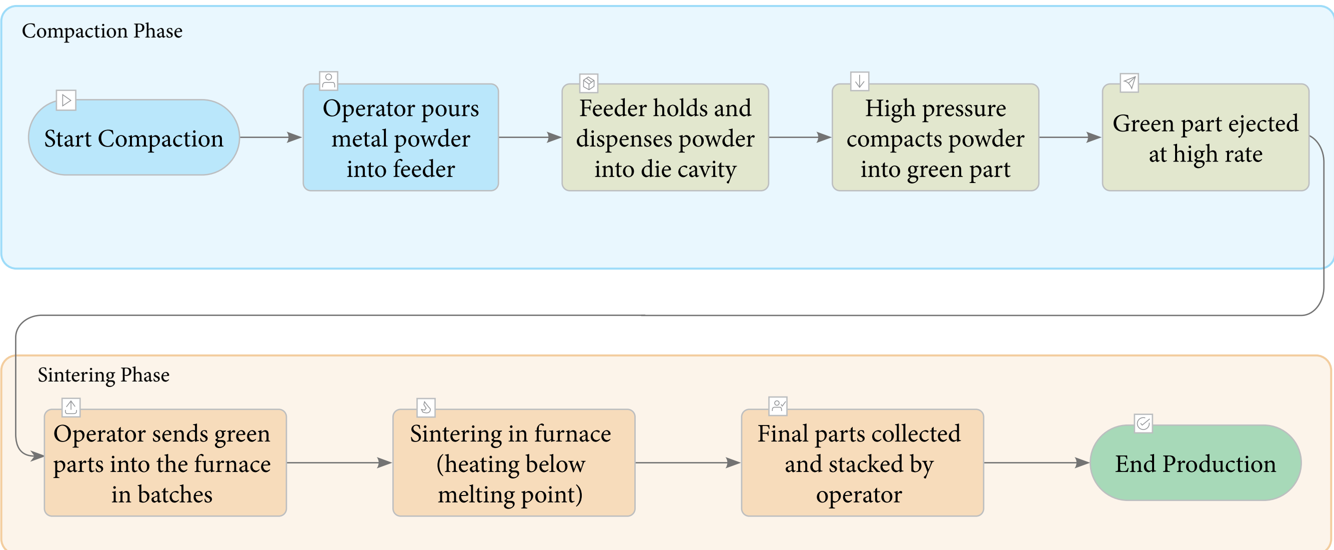
The two-storey building in Manesar has nine machines and 13 operators. The factory is noisy, and workers do not wear uniforms, masks, or special gear. Powdered metal (iron, bronze, copper, etc.) sourced from different parts of the country lay in uncovered round vessels.

The manual process of creating sintered parts has two phases, as shown in Figure 4—the compact press phase and the sintering phase. There are eight compact presses working in parallel to produce "green parts" (a term for a part that is shaped but not yet fully dense or firm) at the rate of 1,000 parts per hour. An operator then loads them in batches onto an assembly line, which transports them into the furnace for sintering. A relatable analogy could be from pottery, where a clay pot is first shaped cold and then fired in a hot kiln to harden it.

If this entire process were to be automated, the powder would automatically be transferred into the feeder via a conveyor system, sensors would detect powder levels, and the whole system would be closed to prevent contamination (Beckwood Press, n.d.).

There is also a welding machine and an area dedicated to packing. Here, all the parts produced are visually checked; those that do not meet the quality standard are rejected, and those that pass the quality checks are packed and dispatched. The visual checkers sit huddled over one end of a table in the despatch room, peering at one part after another, surrounded by boxes.

Figure 4: Fully Manually Operated Sintering Process at Precision Products



Source: AI-generated using Eraser based on prompts given by the author.

5.2 Advantages of Automation

Higher Accuracy and Efficiency

Silver Star (High Automation)

Unlike human operators, industrial robots have much better repeatability and accuracy in their movements. Additionally, they can operate continuously without stopping (Zore et al., 2021). SS's executives explained that before automation, workers conducted manual inspection of each gear produced to ensure quality. However, since thousands of gears were made every day, after a few hours of visual checking, inspectors would experience "visual fatigue", and accuracy would suffer. Replacing workers with automation using AI and cameras led to higher accuracy rates. The operation cycle time is extremely short—four to five seconds—and automation ensures consistency of cycle times, high productivity, and safety standards. These are essential for maintaining a competitive edge in the auto-component industry.

King Auto Parts (Medium Automation)

In KA, a process was shown where a gate has to be closed in a machine once a part is ejected or put inside. When it was done manually, workers would sometimes leave the gate open, and the machine would have to be stopped and restarted, leading to an increase in cycle times. Once it became automated, the gate remained closed while the robot picked up and dropped things through an opening at the top.

- When parts were manually inserted into the mould of the injection moulding machines, there were instances of "insert miss"—an incorrect insertion caused by improper technique. This increased cycle time as the error would have to be corrected. Automation has eliminated such occurrences. Shorter cycle times increase the number of units a machine can produce, thereby improving the productivity of the process.
- The Air Duct Sub-Assembly is a critical part within the heating and air conditioning of a vehicle. When the duct sub-assembly was manufactured manually, as the finished part came out of the machine, a worker would use a cutting knife and cut off the extra trimmings, called runner (akin to cutting off extra thread in a freshly stitched garment). However, when the process got automated, robots cut off the runners, eliminating the risk of injury for the worker and ensuring a more polished final product.

Higher Safety

When workers manually lifted the red-hot parts emerging from the furnace, they faced a constant risk of burns or dropping the components onto their feet. With automation, this task is now performed by a robot, substantially reducing the likelihood of such injuries.

Safety Compromises in Non-Automated Processes

Precision Production (No Automation)

In PP, a compact presser was seen in which a worker places a metal component at the mouth of a machine. He then presses a pedal that activates a press from above, applying high pressure and pushing the part further into the die. This is done to ensure the accuracy of the part size up to 0.002 millimetres. Although pressing the pedal is a deliberate action by the operator, there remains a risk that he could press the pedal and jam his hand in if his hand–eye coordination is compromised, even briefly. The owner agreed with our observation that this process could be easily automated to ensure more safety.

In the workshop on the first floor, a worker was cutting metal without any protective eyewear. When this was pointed out to the owner, he remarked that all workers were given safety gear, such as gloves and goggles, mainly because they supplied parts to a Japanese OEM that conducted inspections of supplier factories and was strict about safety standards. "We have asked them several times to wear their safety equipment, yet our workers refuse to do so, saying it interferes with their efficiency," he said. Sandeep Singh shares that in one instance, due to visual fatigue, his inspectors dispatched one lot without checking the pieces. The consignment was exported to the customer in Germany, who returned it because there were defective pieces that did not fit as required.

5.3 Automation and Labour: Patterns Across the Three Companies

Across the three firms, labour–management relations varied markedly and appeared to correlate with the degree of automation. PP, the company with the least automation and maximum dependency on labour, had the most volatile relationship with its workers. In contrast, the highly automated SS and moderately automated KA displayed a more clinical, transactional association with their workforces. At PP, the indispensability of labour produced a complex mix of loyalty, frustration, and perceived asymmetry. Other than a few long-serving loyalists who were deeply trusted, the management felt that the company invested more in the workers than it received in return.

Permanent and contract labour

Since the beginning of the millennium, as outsourcing gained currency across sectors, the automobile industry has operated with a dual labour structure: permanent and contractual workers. Permanent workers are those directly employed by the company and hence benefit from the company's welfare schemes, such as medical benefits and insurance. They also sometimes earn higher salaries, have security of tenure, and have better prospects. On the other hand, contractual workers are hired through third-party staffing agencies and are not direct employees of the automobile company. There is no minimum requirement for the number of days/ months a contract labourer can be employed for, which gives companies the flexibility to hire and fire as per the production requirement.

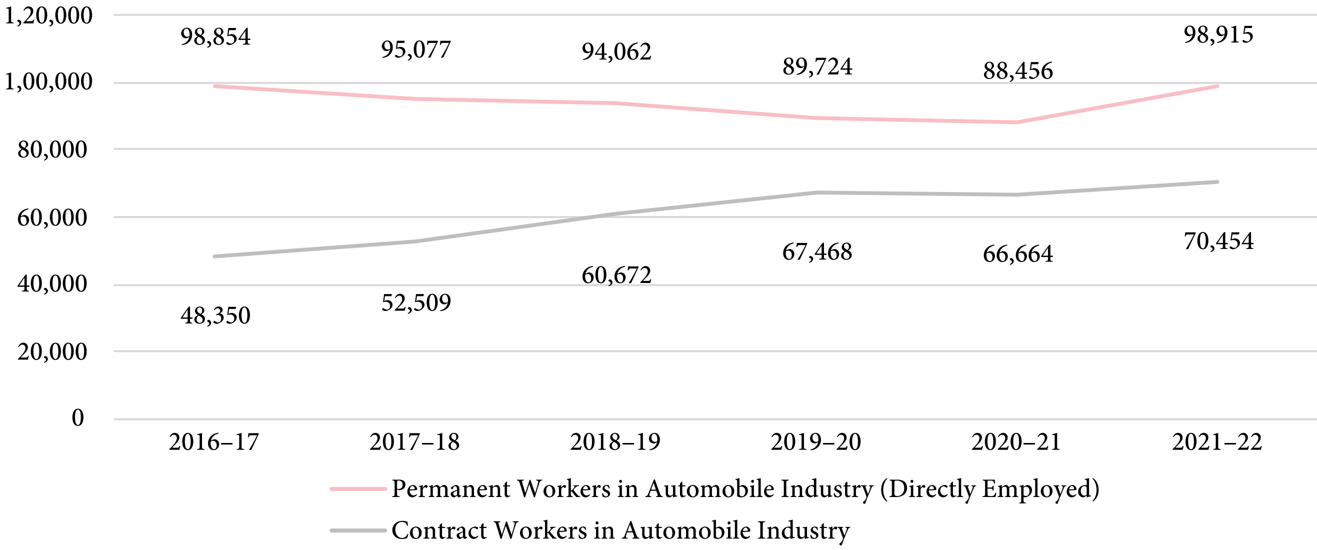
Surajmal, an office bearer in the workers' union at a Tier-1 company that supplies chassis components, explained that when he joined the company in 2008, workers were hired directly onto the company's rolls. New recruits would be taken on for six months and tested, and those who cleared the assessment would be absorbed as permanent staff. This, he noted, ensured that everyone had a genuine opportunity to attain permanent status. Over the years, however, the employment structure shifted. New categories such as "casuals" and "apprentices" emerged, and companies gradually stopped conducting the regular tests that once enabled workers to move into permanent positions.

Successive rounds of PLFS data bear this out. Overall, in India, there has indeed been a significant rise in contractual employment by 30 million. Between 2005 and 2012, the growth in contractual jobs was 2%, but between 2023 and 2024, the annual growth rate was 11.6% (Dubey & Bhandari, 2025). With specific reference to the auto industry, Figure 5 below shows the number of directly employed (permanent) and contractual workers from 2016–17 to 2022–23. The graph points to a steady increase in contract workers in the industry since 2016–17, while the number of permanent workers has largely remained constant, widening the gap between the two types of labour.

"No threat to our jobs"

At present, workers and union leaders in India's automotive factories do not view robots as a threat to their jobs; instead, they recognise that automation enhances quality and productivity. Union leader Bhatti noted that robots are now embedded in every major process and that their numbers have expanded alongside plant growth—from a few assembly lines to several dozen. A robot doing welding and a manual welder work very differently. He added, "If I had to do round welding on a pipe, I would have to stop somewhere, while a jig keeps rotating, while the robot is stationary, and the output will be more uniform." "We don't feel we are threatened because automation only increases company production," said Surajmal.

Figure 5: Trends in the Number of Permanent and Contract Labour in the Automobile Industry



Source: Annual Survey of Industries Volumes with National Industrial Classification Code 2910, which also includes the manufacturing of motor vehicles, semi-trailers and trailers, and the manufacturing of engines of two-wheelers.

Robots can do finer things and more safely. Bhatti cited the example of robotic welding, which delivers greater precision and safety than manual welding: While a manual welder must pause during a circular weld, a jig can rotate continuously under a stationary robot, producing a smoother and more uniform output. Surajmal similarly expressed confidence that automation supports rather than undermines employment, arguing that higher robotisation ultimately increases overall production.

Rakesh Sharma, a union leader at an OEM, offered an even wider perspective. He argued that while automation may reduce the number of workers required inside automobile factories, it simultaneously expands employment elsewhere, particularly in facilities that manufacture robots, where rising demand leads to additional hiring. In his view, the overall effect on workers balances out across the wider economy. Unintentionally, Sharma's reasoning mirrors the conclusion of a PwC (2017) study, which finds that job losses from automation are likely to be offset over time by new employment generated in a larger, more productive, and more prosperous economy.

Silver Star (Tier-1, Highly Automated)

At SS, nearly all 4,500 operators on the shop floor are contractual—even those with 10–15 years of service. Only about 50 long-serving workers have been designated as permanent workers. The company maintains that there is little functional difference between the two groups: Contract workers participate in Kaizen and Quality Circles, wear identical uniforms, share the same canteen, and receive the same medical benefits. Nevertheless, permanent workers earn higher wages, mainly due to their tenure.

As business expanded alongside automation, workers were not displaced but redeployed into new roles that supported automation. For example, maintaining robots and overseeing automated systems required a new set of skills. Workers were retrained to handle these tasks. It was difficult to quantify precisely how many jobs were affected by automation in SS since it had been a seamless and continuous process over the years. The company's stated aim of automating certain processes was to achieve higher levels of safety, quality, and consistency, rather than to replace labour. However, SS's management highlighted a persistent skills challenge: Even ITI graduates required considerable in-house training, given the mismatch between formal curricula and industry needs. Automation enabled them to circumvent this skill gap in the labour force.

King Auto Parts (Small and Medium Enterprise, Medium Automation)

KA pays contract workers between ₹10,000 and ₹20,000, with higher wages for those operating robots. In this firm, wages between contract and permanent operators are similar, but benefits differ—contract workers have no medical leave and are marked absent whenever they fail to report for duty.

The company follows a defined internal mobility path: operator → line-in-charge → shift-in-charge → trainer. Progression depends on individual ability, supported by an annual appraisal and discussion of growth opportunities.

KA bought its first robot in 2016, but the machine remained unused. They decided to operationalise it only post-COVID, when many migrant workers quit their jobs and returned to their villages, leaving them short of manpower. It was then that the company consciously decided to reduce their dependence on labour and gradually transitioned towards automation. Earlier, they were helpless when faced with high attrition during the festival season. Now, with automation, the balance of power has shifted to the management, and they can pick and choose which contractual employees to retain, since they do not need them in the large numbers that they used to.

A process that needed four or five workers now needed three. This does not, however, mean that the other two workers were laid off. Since robots have a software interface, people are required to operate them, and hence, workers are reskilled to be able to do that job. Human labour is also required for quality checks. The company aims to build a human resource pool that is skilled at operating robots. Workers are incentivised to reskill themselves. However, not everyone wanted to. Some workers were happy to continue in the same role, even if it meant earning the same salary. The willingness to learn new skills was not correlated with age but with individual attitudes.

Precision Production (Small and Medium Enterprise, Low Automation)

Due to the specialised training required for sintering technology, PP historically relied almost exclusively on permanent workers. Contract labour was introduced only post-COVID, when several permanent employees did not return from their home states. Skilled roles command higher wages: machine operators earn around ₹21,000–22,000 per month and visual inspectors around ₹30,000.

Across firms, management stated that reliable contract workers can be absorbed as permanent employees. In practice, this is rare: PP has made only seven such conversions since its founding in 2008. The two MSMEs have no unions or external affiliation among workers; at SS, only about 50 permanent workers are unionised.

At PP, management cited a recent example of worker indiscipline where the company had received an order for gears which had to be delivered within a short time frame. A long-serving operator took more than twice the expected time to complete set-up tasks, delaying production despite being told that this was an urgent requirement. Following supervisory intervention, the same tasks were completed the next day promptly, leading management to attribute delays not to skill gaps but to a lax work ethic among the human resources. Such inconsistencies, they noted, increase the supervisory load in small plants where schedules are tightly linked to customer commitments.

Management also described how they have cultivated goodwill over the years: returning from a European trip with personalised gifts for each employee, extending interest-free loans from personal funds to those facing family emergencies, and maintaining what they consider a familial atmosphere. Their oldest employee, now eighty, has worked with the family for over five decades and serves as a packing supervisor while residing on the top floor of the factory building. Yet despite such gestures, the brothers felt that loyalty and reciprocity had diminished over time. They attributed this to what they see as a broader erosion of work discipline, lamenting that "trustworthy, committed workers" are increasingly difficult to find.

Owing to these experiences of labour management on the shop floor, the owners of PP were unequivocal about their long-term aspiration—to automate every feasible operation—two structural constraints create barriers. The first is physical. The current plant layout cannot accommodate the footprint required for industrial robots, particularly those used in sintering and post-processing. The second, and far more consequential, is economic. India remains a marginal player in sintered components, with barely 35 firms operating in this segment, compared to nearly 10 times as many in China. This asymmetry leads to most global orders being cornered by Chinese firms, because Indian firms like PP receive only the small-lot contracts in the range of 5,000–10,000 units per month, while the high-volume orders—0.5 million to 1 million units—that make automation viable are captured by Chinese suppliers. PP nominally lists 1,500 items in its catalogue, but only about 250 attract consistent demand, and even these come in limited quantities of roughly 10,000 units.

Such volumes undermine the logic of automation. Configuring an automated line for a new part requires roughly two hours of setup, followed by one hour of production; a manual operator completes the same batch in two hours. Therefore, when batch sizes are small and changeovers are frequent, automation not only fails to deliver productivity gains but can actually extend cycle times.

Taken together, these cases illustrate three distinct configurations of production technology and labour arrangements. In the next section, these differences are interpreted to understand how automation strategies evolve across firm types.

6. Discussion

Automation in the Indian auto-component industry is unfolding unevenly, shaped by firm size, product characteristics, labour regimes, and skill availability. It is deeply rooted in long-standing structural features of India's auto-component sector.

6.1 Uneven Pathways of Automation

The three firms represent three distinct automation trajectories.

- SS (highly automated) exemplifies the "global Tier-1 company" pathway, where automation is powered by export market pressures, stringent quality standards, large volumes, access to capital and land, and an organisational capability to absorb new technology built in since the firm's early days.

- KA (medium automation) shows a "reactive, labour-driven automation" trajectory. Its post-COVID acceleration of robot adoption stemmed not from technological ambition but from labour volatility, especially absenteeism around festival migrations and the difficulty of retaining workers.
- PP (low automation) is an example of "aspirational automation." Despite being enthusiastic about technology and training its workers in specialised processes, the lack of land and the lack of economies of scale make automation unviable.

These variations demonstrate that automation is highly uneven and dependent on a complex combination of economic and organisational factors, which the paper attempts to explain.

How Industry Structure Shapes Automation Choices

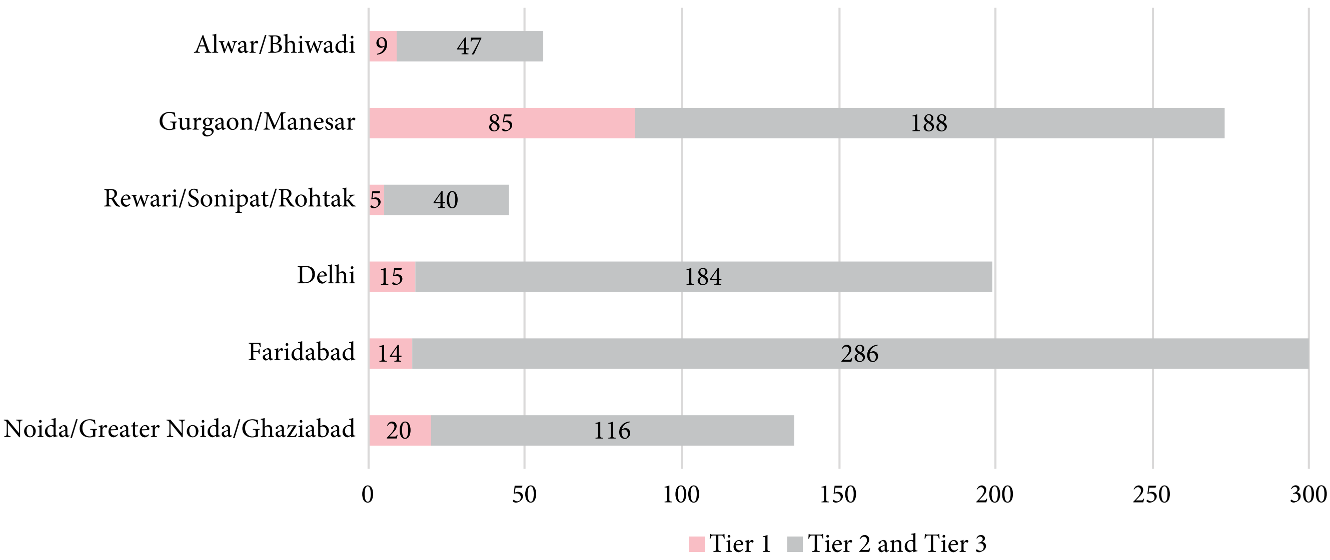
The broader structure of India's auto-component sector helps explain why these three firms have divergent pathways to automation.

Auto components are a subsector of the automotive industry. The component manufacturers are divided into Tiers 1, 2, and 3, depending on the sophistication of the components they produce. Tier-1 companies, for example, manufacture precision instruments required for the vehicle; Tier-2 companies produce individual parts; and Tier-3 consists of firms making the raw material needed for the parts.

Using data from the information portal MarkLines—which is a dedicated portal for the global automotive industry and reports of the industry body ACMA—we attempted to estimate the number of Tier-1, Tier-2, and Tier-3 component manufacturing firms in the auto belt of Delhi–Haryana–Rajasthan. In some cases, the companies were already categorised into different tiers. In others, we used company turnover data and the list of their main customers. As Figure 6 shows, most auto-component manufacturers in Delhi NCR are Tier-3 companies making small parts or raw material. MSMEs or those in the unorganised sector make up 85% of the total, while only 15% are Tier-1 companies. In value terms, however, the numbers are inverted and roughly 80% of the industry's value is concentrated in the few top firms in the organised sector.

For SS, as an export-oriented, Tier-1 company supplying components to the leading OEMs of the world, there is a real need to bring in state-of-the-art technology that will enable it to produce more parts efficiently and compete in global markets. In India, it is a dominant player, supplying components to more than 50% of passenger vehicles and almost all commercial vehicles. Around 3.3% of the company's revenue is allocated to research and development (R&D), a figure higher than the industry standard of 0.5% to 1.5%. It has formed many JVs to access cutting-edge manufacturing technology. Even as far back as 1987, it adopted Japanese management techniques and later formed alliances with American and Israeli companies.

Figure 6: Distribution of Auto-Component Manufacturers in the Delhi National Capital Region



Source: Author's compilation based on the 2019 data from the Automotive Component Manufacturers Association and MarkLines.

Thus, large Tier-1 firms like SS can adopt deep learning inspection systems, smart production monitoring, and multi-robot automation because they have the scale to justify investment, stable order volumes, and access to global technology networks. At the other end of the spectrum are the SMEs like PP, representative of the dominant segment of India's supplier ecosystem, where decisions are driven by unpredictable labour availability and limited capital rather than by long-term technological roadmaps. For such companies, automation is not always technologically feasible or economically rational.

The Role of Labour Markets in Shaping Automation

The Centre for Education and Communication (2021) found that the lower-tier production work was increasingly outsourced to contractors and subcontractors in the automobile production cluster in the Gurugram–Haryana region. This kick-started a process of informalisation in the industry, which has continued since globalisation in the 1990s till the present time. Furthermore, there is a stark difference in the wages and working conditions offered by large factory plants and smaller workshops. In the lowest rung of this value chain, comprising micro-enterprises, workers face harsh conditions like long hours for little pay. Firms often find workarounds so that international labour laws may bind less strongly than in developed countries. For example, Bertrand et al. (2021) detail how Indian firms use contract labour to overcome burdensome labour regulations that otherwise would apply when they reach 100 workers (this limit has been changed to 300 workers under the new labour codes released in November 2025).

In both SMEs in our study, workers were not part of any labour union, and at SS, only 50 out of 4,000+ workers were enrolled in a union. It is against this background that we must situate the finding that labour availability and labour discipline directly influence automation choices, especially in MSMEs.

Post-COVID Labour Volatility

KA's experience reflects a broader labour market reality, i.e., migrant workers' prolonged absences around festivals like Chhath and Diwali, a pattern that has accelerated post-pandemic. Furthermore, with companies hiring more and more people on third-party rolls, the workforce is already facing stagnation in wages and dead-end career paths. On the other hand, workers also have more alternative earning avenues—gig platforms, day trading, online, and content creation—which reduce the attractiveness of shop floor jobs. This labour unpredictability accelerated KA's adoption of robots.

Skill Mismatches

SS repeatedly highlighted the gap between ITI training and factory requirements—consistent with reports from the Automotive Skills Development Council (Ernst & Young, 2019). Even technically qualified recruits need weeks or months of retraining before they can be absorbed into automated lines. Ascertaining whether the workforce is skilled enough to take on future challenges is hard work, and for organisations which can afford it, automation becomes a way to overcome that problem (Ernst & Young, 2019).

Work Discipline and Behavioural Inconsistencies

PP provides an important counterpoint. Labour is permanent and trained, yet management reports considerable inconsistency in effort, adherence to Standard Operating Procedures (SOPs), and discipline. These behavioural frictions raise the supervisory burden and indirectly increase the attractiveness of automation, even when it is not financially justifiable.

Smaller family-run companies are often "tech-phobic" and reluctant to embrace new technologies because they fear they will disrupt their existing processes or that they may not be able to keep up with the pace of change. In this study, both SMEs were eager to switch to automation, primarily to avoid the challenges they faced in dealing with labour, which they believed stymied their efforts to stay competitive.

The three cases together suggest that labour challenges are not merely an input into the production function—they are a central driver of automation strategy.

6.2 The Future Trajectory: Who Gains and Who Lags?

Within five years, the operational stock of industrial robots in India has doubled and reached 33,220 units in 2021. This corresponds to an average annual growth rate of 16% since 2016. There is an increasing adoption of automation in India's automotive industry, though not at the fierce pace at which it progressed in the last 20 years in China. India's robot density in the automotive industry, i.e., the average number of robots for 10,000 people, was only 148 in 2021, while that of China was 772 in that year (IFR, n.d.).

Automation will likely accelerate among large Tier-1 firms, with export exposure, medium firms with chronic labour volatility, and firms moving into electric vehicle (EV) components requiring new levels of precision.

Thus, while larger companies will adapt to Industry 4.0 and reap the benefits of greater automation, such as higher productivity and better-quality products, a large chunk of the auto-component industry, consisting of small firms, may lag, increasing the technological gulf, and by extension the capability gulf, between large and small companies in the industry. This has two implications: imbalances in competitiveness and employment polarisation.

Imbalances in Competitiveness

If MSMEs cannot adopt the next generation of automation—including AI-enabled quality checks, cobots, and smart monitoring—they risk being locked into low-value segments of global supply chains. This can also translate into regional imbalances within India's auto-component industry.

The industry is located in three major clusters: Delhi–Gurugram–Faridabad in the North, Mumbai–Pune–Nashik–Aurangabad in the West, and Chennai–Hyderabad–Bangalore–Hosur in the South. Newer clusters include Sri City and Anantapur in Andhra Pradesh and Sanand in Gujarat.

The northern cluster is the oldest and is dominated by small firms, either in the unorganised sector or small and micro enterprises in the formal sector. Regions that have a higher proportion of Tier-1 firms like SS will have more firms that readily automate, putting them at a competitive advantage.

Employment Polarisation

Automation in manufacturing is expected to reshape the labour market by altering the mix of skills demanded and widening the gap between different categories of workers. As automation deepens, jobs may gradually bifurcate into two broad trajectories:

- High-skill and high-wage roles concentrated in highly automated plants, involving robot programming, monitoring, maintenance, and process optimisation.
- Low-skill and precarious manual roles concentrated in MSMEs that are unable to automate and continue relying on labour-intensive processes.

This bifurcation is consistent with long-standing evidence that digital automation has contributed to rising labour market inequality since the 1980s. Workers who can complement technology—by performing tasks requiring judgment, problem-solving, or cognitive complexity—tend to experience rising compensation, while those whose tasks are substitutable by machines face stagnating or declining prospects. In India, the Centre for Internet and Society, in their report titled "The Future of Work in the Automotive Sector in India" (Bajpai et al., 2019), notes that with the arrival of Industry 4.0, the content of jobs is changing across shop floors in this industry. Robots increasingly handle repetitive and/or hazardous jobs while human workers are taking on tasks that involve higher levels of thinking. Kapoor (2016) notes that increasing capital intensity in the organised manufacturing sector has widened the wage gap between skilled managerial or supervisory staff and less-skilled production workers, thereby contributing to growing inequality.

Holzer (2022) argues that future automation will substitute for a larger range of routine work than earlier waves. Some empirical studies find that increased robot adoption is associated with reductions in the employment share of routine manual task-intensive occupations across industries, including those common in manufacturing (De Vries et al., 2020). Evidence from recent studies shows that low-skilled workers who are displaced often struggle to find jobs offering comparable wages or stability (Petrova et al., 2024).

Automation does not eliminate work but changes its nature. New roles will emerge, but they will demand higher technical skills, particularly in interacting with, supervising, and maintaining automated systems (University of Cincinnati, 2023). As Bughin et al. (2018) show, demand for technological, social, emotional, and higher cognitive skills is projected to rise globally by 2030 as firms reorganise work around automation. Indian evidence points in the same direction. Vashisht and Dubey (2018) find that after full foreign direct investment (FDI) liberalisation in manufacturing, occupations involving manual or routine tasks declined, while those requiring analytical and cognitive capabilities expanded. Complementing this, recent research in the automotive sector indicates that human skills—such as empathy, collaboration, quick decision-making, and complex problem-solving—are gaining in importance as automation advances (Sonal et al., 2024).

Taken together, the broader trajectory of automation implies a gradual restructuring of the labour market. Workers who can adapt to higher-skill roles will likely benefit, while those confined to manual, routine tasks—particularly within MSMEs that lag in automation—may experience increased precarity. The challenge for industry and policymakers is therefore not simply to introduce automation but to ensure that workers can transition into roles that complement, rather than compete with, emerging technologies.

6.3 Policy Implications

Enabling SMEs to Automate

To prevent widening competitiveness gaps between large Tier-1 suppliers and MSMEs, policy interventions must address the structural constraints that limit smaller firms' ability to automate. Recent international evidence shows that automation diffuses more evenly when governments create shared technological infrastructure and reduce the cost of upgrading. For example, Germany's Fraunhofer Institutes now run dedicated programmes to "future-proof" SMEs through subsidised access to robotics testing, prototyping facilities, and AI-assisted quality systems (Fraunhofer Institute for Industrial Engineering, 2021). Similarly, Taiwan's Industrial Technology Research Institute (ITRI) continues to support SME-scale automation by helping with access to finance, small batch production, and accelerating time to market, thereby reducing R&D risks and lowering development costs (ITRI Annual Review, 2024). South Korea provides perhaps the closest policy analogue for India: Its national "Smart Factory" initiative has helped thousands of SMEs adopt modular automation, IoT sensors, and machine-vision systems through government subsidies of 50–70%, technical audits, and mentoring partnerships with large firms (OECD, 2021).

Comparable cluster-level facilities in India would similarly allow MSMEs to experiment with robot cells, digital inspection technologies, and smart monitoring without bearing full capital costs. These could be situated in auto-hubs like Manesar, Pune, and Sriperumbudur. Complementing this, targeted credit support (such as automation-linked credit guarantees, low-interest technology loans, and accelerated depreciation for robotics) can ease the financial burden of upgrading. Strengthening vendor-development programmes, where Tier-1 firms co-invest in process improvement, training, and technology audits for suppliers, mirrors recent European and East Asian programmes that have successfully raised SME productivity (Segarra-Blasco et al., 2025). Finally, developing automation-ready industrial spaces—with adequate floor loading, ceiling heights, and utilities—would help MSMEs overcome the physical constraints that currently prevent robotic installation. Together, these measures can help narrow the capability gap between firm tiers and prevent technological upgrading from deepening regional disparities within India's auto-component industry.

Tackling Labour Market Polarisation

There is a need for more programmes under the Skill India Mission, such as the Industrial Robotics & Digital Manufacturing Technician Program, offered under the Craftsmen Training Scheme (CTS) by the Directorate General of Training (DGT), which focuses on equipping trainees with hands-on experience with industrial robots, including programming, operation, and maintenance. These programmes offered by ITIs often have low enrolment due to a lack of awareness about the course, along with other challenges that ITIs face in attracting students (Maitra, 2019). In 2022, the most recent year for which data are available for ITI courses, there were 14,946 seats available for this course across ITIs, but only 956 students had enrolled (Ministry of Skill Development and Entrepreneurship [MSDE], n.d.). Given the immense scale of the exercise of skilling, the government cannot achieve this objective alone. Companies must be stakeholders, as the lack of skilled workers affects them directly. There are some examples of major auto companies that have adopted ITIs and brought the students up to speed. Bosch Limited has created a new "Skill Development Center" at the Government ITI in Bengaluru, to upskill ITI students with industry-relevant skills. Japanese India Institute for Manufacturing (JIIM) is a fully residential institute set up in Mehsana by Maruti–Suzuki to train the youth for the manufacturing sector.

While policy response should ensure that education and skill development opportunities are accessible to all, particularly to the less privileged, in reality, not all workers can reskill themselves to the required level, due to various barriers such as age, gender, opportunity, and individual ability. Hence, the low-skilled workers who will invariably be displaced need to be reinstated in "decent work," i.e., quality jobs, along with social protection and respect for rights at work (ILO, 2025). The need for this is already evident because PLFS and National Sample Survey Office (NSSO) data show that between 2017–2018 and 2023–2024, employment growth was highest among better-educated and skilled workers, while it remained stagnant or even negative for low-skilled and less-educated workers. Targeted retraining and upgrading programmes can help vulnerable groups transition into new roles rather than exit the labour force entirely (Lerch, 2025).

Structured public support systems in other countries offer examples of how transitions for displaced workers can be managed. Germany's *Kurzarbeit i*s often considered a gold standard of such programmes. It is a social insurance programme whereby employers reduce their employees' working hours instead of laying them off. Under *Kurzarbeit*, a displaced worker receives 60% of his or her pay for the hours not worked, while receiving full pay for the hours worked (International Monetary Fund, 2020). Denmark's labour market combines flexible hiring and firing with strong active labour market policies under a "*flexicurity*" framework. It supports workers made redundant for economic reasons, through training and income security during job transitions (OECD, 2016).

7. Conclusion

This study examined how automation is taking shape in three auto-component firms that differ in size, product complexity, and labour needs. Across the cases, the findings show that automation in India is advancing, but not in a uniform way. It grows quickly in large firms where customers demand high accuracy and traceability, moves selectively in mid-sized firms that face labour shortages, and remains limited in small firms that work with small orders, tight margins, or space constraints. Thus, automation in the Indian auto-component sector is strongly shaped by the structure of the industry.

The second RQ attempted to explore the implications of automation. As was evident in the case of the first two companies—with fully and semi-automated processes—there are huge advantages in terms of greater accuracy, efficiency, productivity, and worker safety. In contrast, the small firm that has only manual processes continues to function with a high level of safety risk and inconsistency in quality.

The evidence suggests that, at present, automation is not replacing workers on any significant scale, but it is changing what different workers do. In larger firms, operator roles are moving steadily toward supervision, monitoring, and problem-solving. In mid-sized firms, workers who handle robots or automated cells gain new responsibilities and better pay, but manual tasks continue alongside automated ones. In small firms, limited automation means labour remains central, but firms struggle with inconsistent work practices. These differences point to a gradual widening of skill levels and changing job roles in the auto-component factories, rather than widespread job loss.

Taken together, these cases speak to a broader structural pattern. India's auto-component industry is dominated by MSMEs, and this shapes how far and how fast automation can spread. Larger firms will continue to adopt more advanced systems, while many smaller firms may lag unless they receive targeted support. This has implications not only for productivity gaps within the industry but also for the types of opportunities available to workers. The future is likely to see a growing demand for technical, digital, and problem-solving skills, even for shop-floor roles that were earlier considered routine.

If India wants a more even spread of automation and better-quality jobs, small- and mid-sized firms will need help in technology adoption and training. Workers, too, will need opportunities to upgrade skills so that they can work with new forms of automation rather than be pushed to the margins of the labour market. Supporting firms and workers together is essential if automation is to serve as a pathway for industrial upgrading rather than a source of widening gaps.

Two future areas of research stem from this paper. The first is to do with India's new draft Labour Codes of 2025, which formally introduce fixed-term employment (FTE) as a recognised category, to promote direct hiring and help reduce excessive contractualisation. Fixed-term employees are entitled to the same statutory benefits as permanent employees, including leave, medical, and social security. They are entitled to equal wages as permanent staff. They are now eligible for gratuity after just one year of employment, instead of five as before (Press

Information Bureau, 2025). Whether FTE becomes significant in industrial settings, replaces contractual labour, and how it interacts with automation and skill formation, is a useful avenue for future research.

The second is related to retraining mid-career blue-collar workers. Although the MSDE offers numerous skilling programmes for entry-level workers, programmes for mid-career workers are few. The Dattopant Thengadi National Board for Workers Education and Development (formerly the Central Board for Workers Education) has been recognised by the National Council for Vocational Education and Training (NCVET), under the MSDE, Government of India, and is the designated body to design and develop curricula across sectors and implement them at the ground level. Among other training programmes, it runs an "Employability and Proficiency Enhancement Program" designed to mitigate the acute domain and employability skill gap (Press Information Bureau, 2025). These gaps are expected to increase as industries like automotive adopt automation at a faster rate going forward. The ability of these programmes to reskill workers to adapt to changing modes of production could be a useful area of study.

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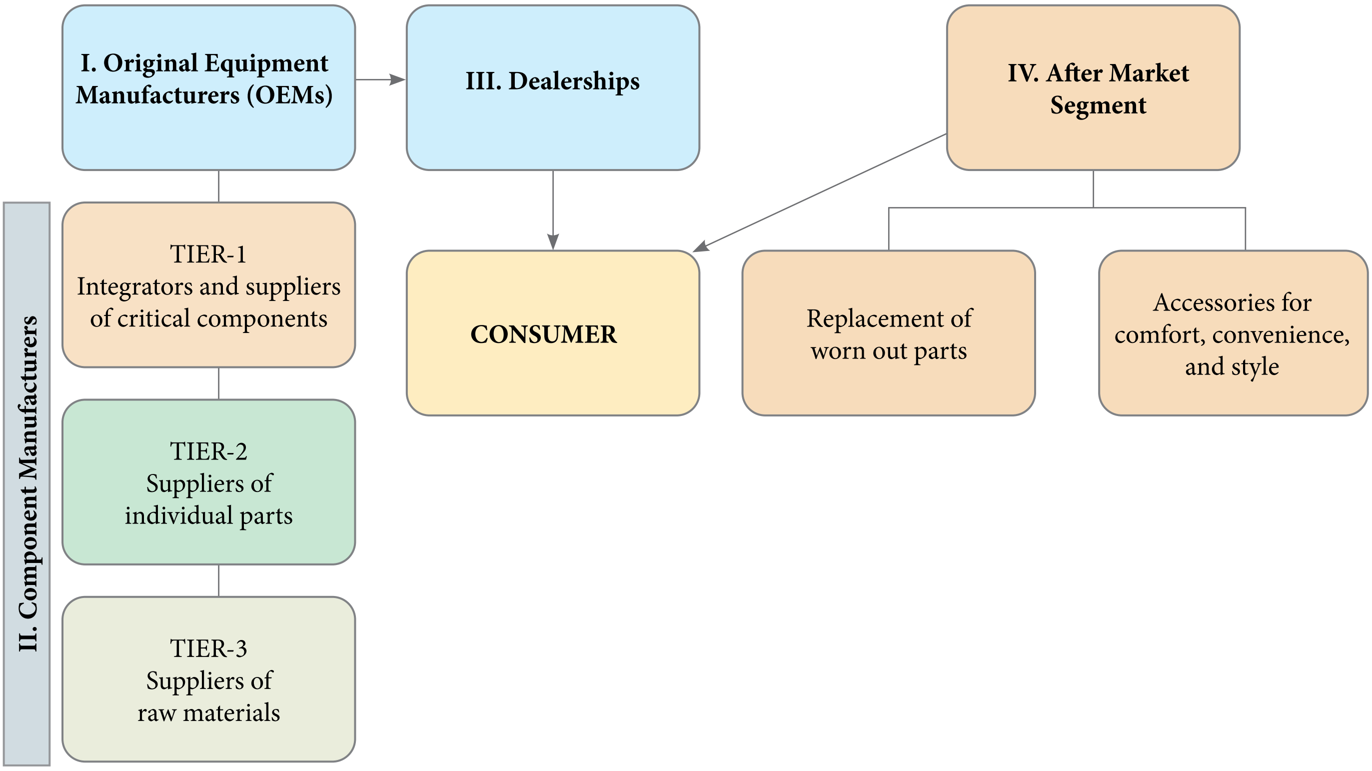
Appendices

Appendix 1: Auto Ecosystem in India



Source: Author's compilation.

Appendix 2: Quotations from Interviews

- "It is not a switch, that suddenly the ice age is over, and a new age has begun." (CTO, SS, to indicate that automation is a seamless, continuous process [August 7, 2024]).
- "The challenge is that there is no ready pool of skilled workers who can start contributing within days of being hired." (CTO, SS [August 7, 2024]).
- "Even if some workers are reduced from automobile factories because of automation, somewhere in the robot manufacturing factories, more people are hired because more robots are being manufactured. So overall for workers, it evens out." (Rakesh Sharma, Union leader at an OEM [January 8, 2025]).
- "If I could, I would kick out half my employees, not just workers but half of the 70 people I employ, tomorrow, and replace them with robots." (Sandeep Singh, owner, Precision Products [January 31, 2025]).
- "Speaking from the perspective of an entrepreneur who is unable to automate, the problem that we face is that people don't want to work. But you can programme a robot. It will keep working, whether it is lunch or tea-time, and you don't have to give Provident Fund (PF) and Employees' State Insurance (ESI): no casual leave, no earned leave, no Diwali holidays, no bonus. We have to give all this to workers, and in return, what do you get? Nothing much." (Sandeep Singh, owner, Precision Products [January 31, 2025]).
- "Employment contracts are only for 240 days; legally, a worker employed for longer than that must be taken on the rolls. So, after 240 days, contract workers are fired and rehired. They keep starting in the same place and remain contract workers forever. Their capability and education are the same as those of the permanent workers. Just that they joined later. The law says same work, same pay, but the company doesn't implement it." (Prakash Bhatti, union leader [January 30, 2025]).

Appendix 3: Discussion Guide

A3.1 Questions for Companies

1. What are the different kinds of technologies currently being used in the production process of your product offerings? If different technologies are used in the production of different products, could you distinguish and specify?
2. How did SS come to learn about these technologies and implement them?
3. What factors were considered in the decision to shift to automation?
4. What are the processes that currently use workers?
5. What production processes and tasks are currently completely automated? What processes are partially automated?
6. What kinds of components/products have a higher degree of automation within their manufacturing process as compared to others?
7. When did you first start installing robots for manufacturing? What prompted the decision to install robots?
8. What kind of robots do you currently use and for what tasks?
9. How has the workforce been impacted by automation in your company? If workers have been laid off, how were they compensated?
10. Has automation led to the creation of new jobs? If so, what kinds of jobs have emerged?
11. How has the company been impacted since the introduction of automation (for example, in terms of performance, growth, productivity, efficiency, etc.)?
12. What are the pros and cons of automating production processes?
13. How do you envision the future of the company with regard to automation? What role do you think human resources will play within your organisation and production activities?
14. Is SS planning to expand its adoption of newer technologies (like robots, AI, etc.) for production?
15. Where do the plants in India stand with regard to automation as compared to the plants in the other countries that you operate in?

A3.2 Questions Asked to King Auto Parts and Precision Production

Information about the firm:

1. How long have you been operating in this industry?
2. What are the main products manufactured by you?
3. Do you produce components for EV and Internal Combustion Engine (ICE) vehicles? If yes, how is the production process different?
4. Who are your main customers? Are they large companies/small companies or domestic/foreign?

Automation:

5. Have you introduced automation into your production process? If yes, when did it start, and for what tasks is it currently being used?
6. What kinds of robots or technology are you currently using?
7. How does your level of automation compare to larger companies in this industry?

Workers:

8. How have workers been managed after the introduction of automation? Have they been reskilled/redeployed?
9. What new skills have become important after automation? Were any new jobs created? If so, how many new jobs?
10. What skills/jobs have become redundant?
11. How do you train or prepare workers for working with automation?
12. Do you face challenges in finding labour—skilled or unskilled?
13. How do you balance the need for skilled workers with the traditional labour-intensive nature of small-scale manufacturing?

Decision to Automate:

14. What factors went into the decision to automate?
15. Have larger companies or customers influenced your decision to automate?
16. Have you collaborated with other firms for automation? How has the automation been procured/financed?

17. How does the cost of labour compare with that of automation?
18. Has automation helped your firm's performance? Has it helped give you a competitive edge over other firms or reach the level of larger firms?

Future Outlook:

19. Where do you feel your firm will stand in this industry in the face of increasing automation?
20. How do you see the role of smaller manufacturers evolving in an increasingly automated industry?
21. What concerns do you have about increasing automation in the industry?
22. How do you feel your firm's labour demands will change with the increasing adoption of automation?

Government Support:

23. Do you know of any government schemes that can support your firm or any schemes that can help you adopt the latest technology?
24. What more support do you think you need from the government as a small-scale manufacturer?

Innovation & Quality:

25. Does your firm innovate? How may this have changed with automation?
26. Has the quality of your product changed after automation?

A3.3 Questions for Union Leaders

Work Experience:

1. How long have you been working in this industry?
2. What roles have you held within this industry? How has it changed over time?
3. If you have worked at a larger/smaller firm in this industry, how has the experience been different?
4. How has the use of contract/temporary labour changed at your workplaces?

Automation:

5. In your work, have you worked with automation? If yes, when did automation first start in your job?
6. What do you feel are the pros and cons of automation in your work?
7. Were any of your tasks/work replaced partially or entirely by automation?
8. Have you ever been moved to a different department because of automation?
9. Have you been reskilled because of automation? If yes, what skills?
10. Has automation affected your work hours or patterns?
11. Has automation impacted the safety at your workplace?

Job Security & Pay:

12. Have you ever lost a job to automation in this line of work/industry?
13. How secure do you feel your job is in the face of increasing automation?
14. Has your pay changed after automation entered the picture?
15. Has automation affected any health concerns that you may have faced at work?
16. What support do you think workers need to adapt to the changes in this industry in the face of automation?

Unionisation:

17. Are you part of any unions?
18. How have these organisations reacted to automation?

Company Responses:

19. Has your company offered you and your colleagues any training after introducing automation?
20. How has the work environment changed before and after automation?
21. How responsive has your company been in attending to employee requests regarding help with automation?

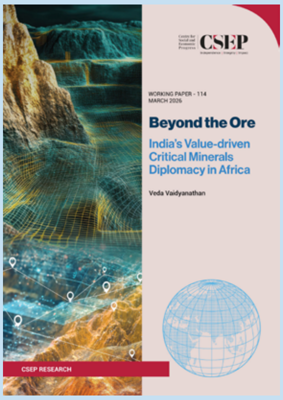
About the author

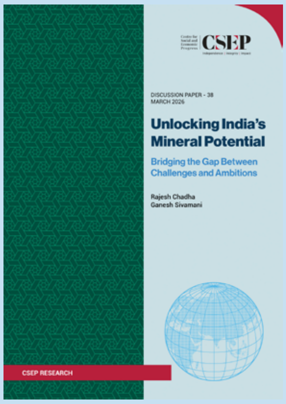
Vandana Vasudevan is an urban development scholar, author, and columnist whose work spans mobility, gender, transport, the gig economy, technology, and society. She holds a Ph.D. in Urban Studies from Université Grenoble Alpes, France where her research focused on the mobility of urban working women. A Visiting Fellow at the Centre for Social and Economic Progress (CSEP), she has consulted for the Asian Development Bank (G20 Track), Microsoft Research, the World Bank, WRI and IFC.

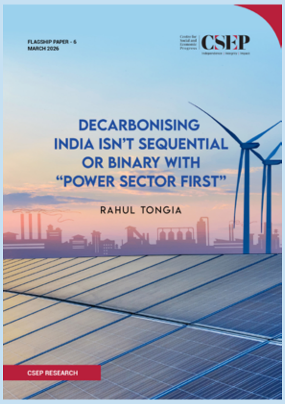
Before entering academia and policy, she held leadership roles at HT Media, ICICI Bank, and Standard Chartered Bank, after completing her PGDM from IIM Ahmedabad. She is the author of three non fiction books, most recently of *OTP Please! Online buyers, sellers and gig workers in South Asia* (Penguin Random House, July 2025)

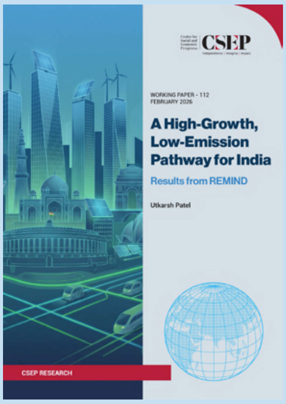
She writes extensively for major Indian newspapers and combines rigorous scholarship with an engaging, lively voice that makes her work both insightful and deeply relatable.

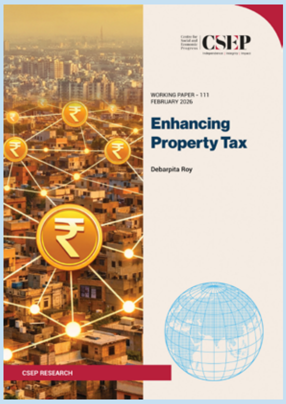
Other publications

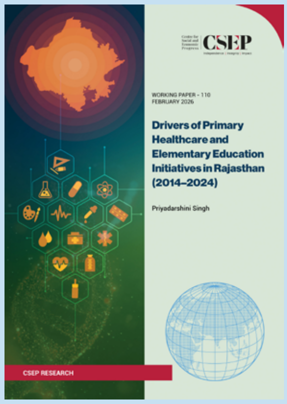


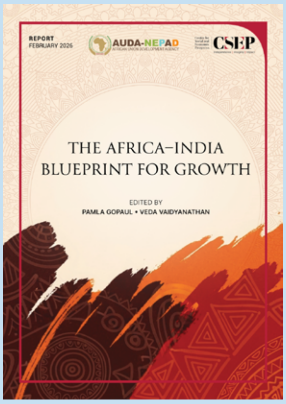


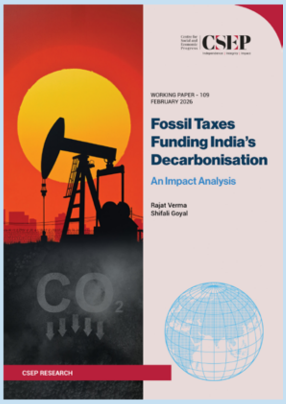












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