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Sunil Mani

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Sunil Mani, Visiting Professor, Centre for Development Studies,

Ahmedabad University, India, mani@cds.edu

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ABSTRACT

This paper analyses the stark divergence in industrial robot adoption between China and India, benchmarking their trajectories in terms of scale, density, and sectoral and task diversity. Employing a three-factor analytical framework—labour market pressures, industrial structure, and government policy—the study explains China's rapid, state-orchestrated automation, which has bolstered export competitiveness despite rising wages. In contrast, India's adoption remains incremental and concentrated, constrained by its labour-abundant economy and less activist policy stance. The analysis reveals distinct implications: China enhances economic resilience but faces social risks from workforce displacement, while India preserves employment stability at the cost of global competitiveness and productivity. The findings underscore the critical need for policy realignment in both nations to harness the benefits of automation while mitigating its socioeconomic costs.

Keywords: Industrial Robotics, Automation, China, India, Technological Divergence, Industrial Policy

JEL: J24, O33, O14, L52, O53

1. Introduction

In an era defined by rapid technological disruption, the adoption of industrial robots stands as a cornerstone of modern manufacturing, enhancing productivity, competitiveness, and adaptability to evolving global value chains (Graetz & Michaels, 2018). As the world's two largest emerging economies, China and India embody the transformative potential of automation within labour-intensive sectors. However, their trajectories diverge starkly: China has emerged as the global leader in both robot usage and production, driven by strategic state policies, while India remains an aspirant market, grappling with distinct economic constraints (International Federation of Robotics, 2024). This paper examines the causes and consequences of this divergence, exploring how automation influences the manufacturing futures of these powerhouses.

The motivation for this analysis stems from a profound puzzle. Despite shared ambitions to dominate global manufacturing, China and India exhibit markedly different adoption patterns and outcomes. China's labour arbitrage—once its hallmark competitive edge—has eroded amid surging wage rates; yet, the country has not only preserved but also amplified its export prowess in numerous sectors (Financial Times, 2025). This defies conventional wisdom that low wages alone propel exports, raising a critical question: has automation served as the linchpin in surmounting rising costs? In contrast, India's cheaper labour has muted the urgency for widespread robotic integration, fostering a more incremental approach concentrated in niche industries, such as automotive components (Mani, 2024). Understanding these drivers is not merely academic; it holds profound policy implications for crafting resilient industrial strategies and discerning emerging hubs in fragmented global supply chains.

Engagement with the extant literature underscores the economic stakes. Empirical studies affirm a positive causal link between robot adoption and productivity gains, with aggregate analyses across 17 advanced economies revealing an annual labour productivity uplift of 0.36–0.37 percentage points, driven by output expansion rather than mere capital deepening (Graetz & Michaels, 2018). At the firm level, however, benefits hinge on complementary investments in process re-engineering, workforce reskilling, and management restructuring, maximising human-machine synergies (Graetz & Michaels, 2018). However, this optimism is tin empered by the labour-displacement paradox: while macroeconomic evidence shows no net employment erosion—thanks to productivity-induced demand elsewhere—micro-level disruptions are evident, as one additional robot per thousand workers in the United States reduced the employment-to-population ratio by 0.2–0.4 percentage points (Acemoglu & Restrepo, 2020). For emerging economies like China and India, these tensions amplify, where automation could either sustain export-led growth or exacerbate inequalities in informal sectors.

To dissect this divergence, the paper benchmarks the scale, pace, and sectoral composition of robot adoption in both nations, drawing on comprehensive data from the International Federation of Robotics (2024). It probes the 'Chinese puzzle'—how automation has buttressed robust export expansion despite wage pressures—and identifies pivotal drivers through a three-factor framework: labour market pressures (rising wages and ageing demographics), industrial structure and scale (enormous labour-intensive manufacturing bases), and activist government policies (subsidies and national missions). By elucidating these synergies in China versus their misalignment in India, the analysis reveals not just divergent paths but actionable pathways for equitable automation in the Global South.

In sum, as automation reshapes manufacturing paradigms, the China-India contrast illuminates a broader imperative: harnessing robotics to transcend low-wage traps without forsaking labour's role. This essay contends that while China's orchestrated ascent offers a blueprint for scale, India's challenge lies in forging policy alignments to democratise adoption, lest it risk a bifurcated economy of automated enclaves and stagnant peripheries.

2. Motivation

Industrial robot adoption represents a defining global trend in modern manufacturing, serving as a critical lever for enhancing productivity, competitiveness, and resilience amid shifting global value chains. Despite their status as the world's two largest emerging economies with expansive manufacturing ambitions, China and India display starkly divergent trajectories in robot uptake and outcomes, presenting a compelling puzzle. In China, the erosion of its traditional labour arbitrage—driven by rapidly rising wage rates—has not diminished its export prowess; rather, it has amplified competitiveness across multiple sectors, challenging the conventional model that low wages alone sustain export-led growth. This central paradox prompts a vital question: has automation emerged as the key mechanism for overcoming escalating costs? Addressing this divergence is not merely an academic endeavour but a policy-relevant imperative, essential for formulating robust industrial strategies and evaluating prospective global manufacturing hubs.

3. Objectives

The objectives of this analysis are threefold, aimed at dissecting these contrasting paths with precision. First, it benchmarks and compares the scale, pace, and sectoral composition of industrial robot adoption in both nations, highlighting disparities in deployment and intensity. Second, it scrutinises the 'Chinese puzzle', investigating how China's aggressive automation drive has enabled sustained export expansion despite the diminishing low-wage advantage, thereby illuminating pathways to technological resilience. Third, it identifies the core drivers underpinning these trajectories, encompassing economic pressures, structural features, and policy interventions, to offer actionable insights for emerging economies navigating similar transitions.

4. Review of Literature

Engagement with the literature reveals a nuanced economic landscape surrounding robot adoption, balancing opportunities for growth against risks of disruption. On productivity enhancement, empirical studies consistently establish a positive causal relationship, with aggregate evidence from 17 countries indicating that robots elevate annual labour productivity growth by 0.36 to 0.37 percentage points, primarily through expanded output and value added rather than simple capital deepening (Graetz & Michaels, 2018). At the firm level, however, these gains are contingent upon complementary investments, including process re-engineering, workforce reskilling, and management restructuring, with the greatest benefits accruing from seamless human-machine integration. Yet, this progress is shadowed by the labour-displacement paradox: macroeconomic analyses show no net reduction in total employment, as productivity gains stimulate higher output and demand, creating jobs elsewhere in the economy (Graetz & Michaels, 2018). In contrast, micro-level evidence highlights localised disruptions. In the United States, for instance, each additional robot per thousand workers is associated with a

0.2 to 0.4 percentage point decrease in the employment-to-population ratio, exerting downward pressure on wages and jobs (Acemoglu & Restrepo, 2020). Extending this to emerging economies, firm-level data from China's manufacturing sector—representative of over 80 percent of its robot use—reveal an adoption rate of 8.6 percent in 2015, concentrated in automotive and electronics industries mirroring global patterns, yet driven by distinct factors such as rising labor costs (9.7 percent annual wage growth from 2005–2016), high voluntary turnover, and a prevalence of manual tasks, rather than routine cognitive ones (Cheng et al., 2019). Unlike Western contexts, Chinese firms show no heightened anxiety over job replacement, bolstered by government subsidies (linked to 15 percent of adopters) and policies like "Made in China 2025," which frame automation as a tool for industrial upgrading amid demographic deficits (e.g., shrinking working-age population since 2015). For China and India, these dynamics amplify the stakes, where automation could either fortify export competitiveness—leveraging China's dominance in global auto and electronics production—or widen inequalities in labour-intensive sectors, though China's proactive reskilling narratives (e.g., shifting workers to technical roles) suggest potential mitigation of micro-level shocks.

Building upon the analysis by Cheng et al. (2019), who examined the determinants and implications of industrial robot adoption specifically within China, we extend this line of research by introducing a comparative dimension. While Cheng et al. focused on explaining China's rapid rise in robot density through factors such as rising wages, labour shortages, industrial upgrading, and strong policy support, we situate China's experience alongside that of India to highlight why two similarly large emerging economies have followed markedly different trajectories of automation. Our study advances the literature in four important ways. First, we introduce new empirical indicators—the Robot Diversity Index (RDI) and Task Diversity Index (TDI)—to capture the breadth and complexity of robot use across industries and tasks, providing a richer picture than aggregate installation data. Second, we develop a three-factor analytical framework that links labour market dynamics, industrial structure, and state policy activism, thereby integrating economic, structural, and institutional explanations of technology diffusion. Third, we extend the analysis to the post-2016 period, capturing recent developments in robot adoption, domestic production, and policy interventions that have further shaped divergent trajectories. Fourth, while Cheng et al. analysed China's experience largely within a national framework, we adopt a comparative political economy perspective, showing how China's coordinated, state-led automation contrasts with India's fragmented, firm-driven approach. By embedding technological adoption within the broader context of industrial policy and development strategy, we deepen the understanding of how structural asymmetries and policy capacities shape divergent paths of automation in emerging economies.

5. Analytical framework

To unpack this divergence, the analysis employs a three-factor framework that elucidates the interplay of economic imperatives, structural conditions, and policy activism in driving robot adoption. The first factor, labour market pressure, encompasses a vast workforce confronting rapidly rising wages and an ageing population, generating a potent economic incentive to substitute expensive, scarce labour with automation. The second, industrial structure and scale, hinges on the presence of an enormous manufacturing sector dominated by large-scale, labour-intensive industries such as automotive and electronics, which furnish the requisite scale and use cases to engender endogenous demand for robots. The third, activist government policy, involves proactive state interventions—through subsidies, tax incentives, and national missions—that treat automation as a strategic priority, de-risking investments, accelerating technology diffusion, and aligning domestic capabilities with global market exigencies. Collectively, the convergence of these factors in China forges a self-reinforcing cycle of rapid, widespread adoption, whereas their misalignment in India constrains progress to incremental, sector-specific advances.

Figure 1 visually illustrates the interplay among three core factors that explain the divergent paths of industrial robot adoption across countries such as China and India.

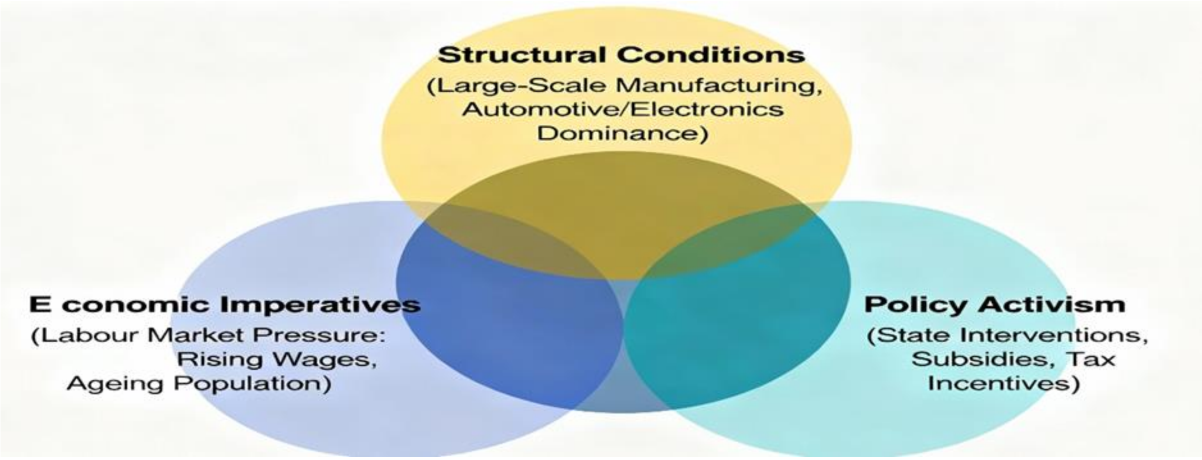

Figure 1: Visual representation of the analytical framework
Source: Author's own compilation

- Economic Imperatives (Labour Market Pressure): At the top, the diagram highlights how rising wages and an ageing population create powerful incentives for automation. As labour becomes more expensive and scarce, firms face pressure to substitute workers with robots, thereby accelerating the adoption of automation.
- Structural Conditions (Industrial Scale): The second factor focuses on the size and composition of the manufacturing sector. Countries with large, labour-intensive industries—especially automotive and electronics—have the necessary scale and use cases that drive robust, endogenous demand for robots.
- Policy Activism (Government Intervention): The third circle covers state-driven interventions, like subsidies, tax incentives, and national missions. Activist policies reduce investment risks, speed up technology diffusion, and strategically align domestic capabilities with global competition.

In China, all three factors overlap strongly. Labour pressures are acute, the manufacturing sector is vast, and the government prioritises automation, forming a self-reinforcing cycle that drives rapid, widespread robot adoption. In contrast, India experiences only partial alignment: manufacturing is less central, policy support is less aggressive, and wage pressures are lower, resulting in slower and more fragmented adoption, limited to specific sectors.

The figure underscores that the successful diffusion of robots is not just a matter of technology, but also of how economic necessity, industrial structure, and policy interact. Where these forces converge, adoption accelerates; where they do not, progress remains incremental.

6. Data Source

The data source underpinning this analysis is the *World Robotics 2024* report from the International Federation of Robotics (IFR), a comprehensive annual publication that compiles global statistics on industrial robot adoption, providing a robust foundation for cross-country and sectoral comparisons. At its core, the report's series encompasses key metrics such as annual installations—representing the number of new robots deployed each year—operational stock, which captures the cumulative number of robots actively in use at year-end, and robot density, measured as robots per 10,000 manufacturing employees, offering a standardised gauge of automation intensity across economies. These variables are richly disaggregated to enable nuanced insights: by country or region, covering approximately 40 nations; by customer industry, including automotive, electronics, metal, plastics, food, pharmaceuticals, and others; and by application or task, such as handling, welding, assembly, painting, and machine-tending, allowing for detailed examination of deployment patterns. The time coverage spans annual time series, generally from 1993 to the present, ensuring longitudinal depth for tracking trends over three decades. The geographical scope encompasses approximately 40 countries across Asia, Europe, the Americas, and other regions, with a particular emphasis on manufacturing hubs such as China and India. Operational stock is calculated as the cumulative sum of past installations, adjusted for an approximate 12-year service life of robots, realistically accounting for depreciation and obsolescence. Data sourcing draws on primary supplier returns from major robot manufacturers, complemented by inputs from national robotics associations and secondary statistics, thereby blending direct industry reporting with validated external corroboration to enhance reliability and accuracy. Among the key indicators published, the report highlights annual installations, operational stock, robot density, distributions by industry and task, as well as regional and global totals, furnishing a holistic dataset that not only quantifies the scale of adoption but also illuminates its structural and applicative dimensions, making it indispensable for dissecting divergent paths in robot uptake between emerging economies.

7. Indicators of Divergence

The rapid integration of industrial robots into manufacturing represents a pivotal shift in global production paradigms, promising enhanced productivity and competitiveness amid evolving labor dynamics. Yet, as two of the world's largest emerging economies and manufacturing powerhouses, China and India exhibit starkly divergent trajectories in their adoption of robots. China's ascent as the global leader in robot installations and production—driven by strategic state policies and economic imperatives—contrasts sharply with India's more nascent and incremental approach, constrained by structural and demographic factors. Drawing from Sunil Mani's lecture "Divergent Paths of Robotics Adoption in China and India" (delivered on November 11, 2025, at Ahmedabad University), this essay examines key indicators of this divergence. These include the scale of adoption (annual installations and operational stock), robot density, sectoral and task diversity, import dependence, and domestic production self-reliance. By benchmarking these metrics, the analysis reveals how China's aggressive automation offsets eroding labour cost advantages, while India's cautious approach reflects untapped potential amid an abundance of low-cost labour.

7.1 Scale of Adoption: Installations and Operational Stock

A key indicator of the divergence between China and India in industrial automation is the sheer volume of robot deployment, as illustrated in Figure 2. This figure presents the ratio of China's operational stock of industrial robots to that of India, providing a clear visual representation of the scale gap. The contrast is striking: while China's cumulative robot stock has grown exponentially over the past decade, India's adoption remains comparatively modest. Figure 2 not only highlights the quantitative disparity but also underscores the broader implications for productivity, industrial sophistication, and technological capability. The widening gap reflects differences in economic imperatives, policy support, and industrial structure, signalling how deeply divergent automation trajectories have become between the two largest emerging economies.

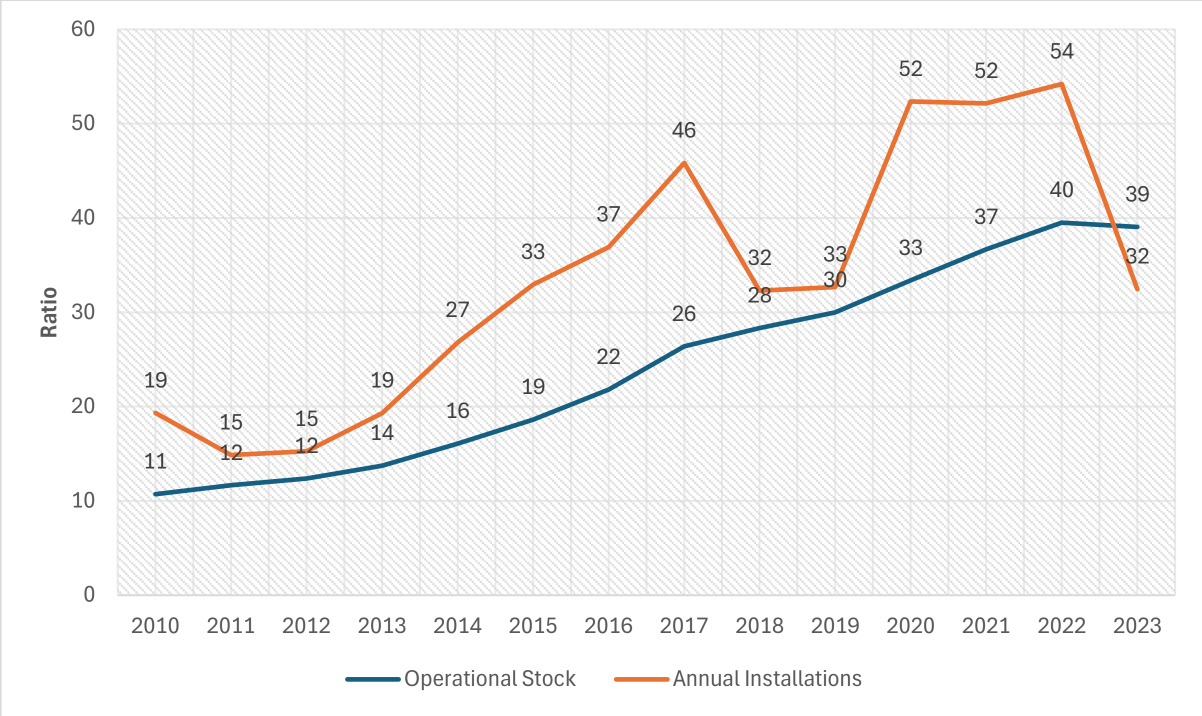

Figure 2: Ratio of the operational stock of industrial robots in China to that of India

Source: International Federation of Robotics (2024)

China's dominance is evident in both annual installations and cumulative operational stock, underscoring its scale advantage over India. See Figure 23

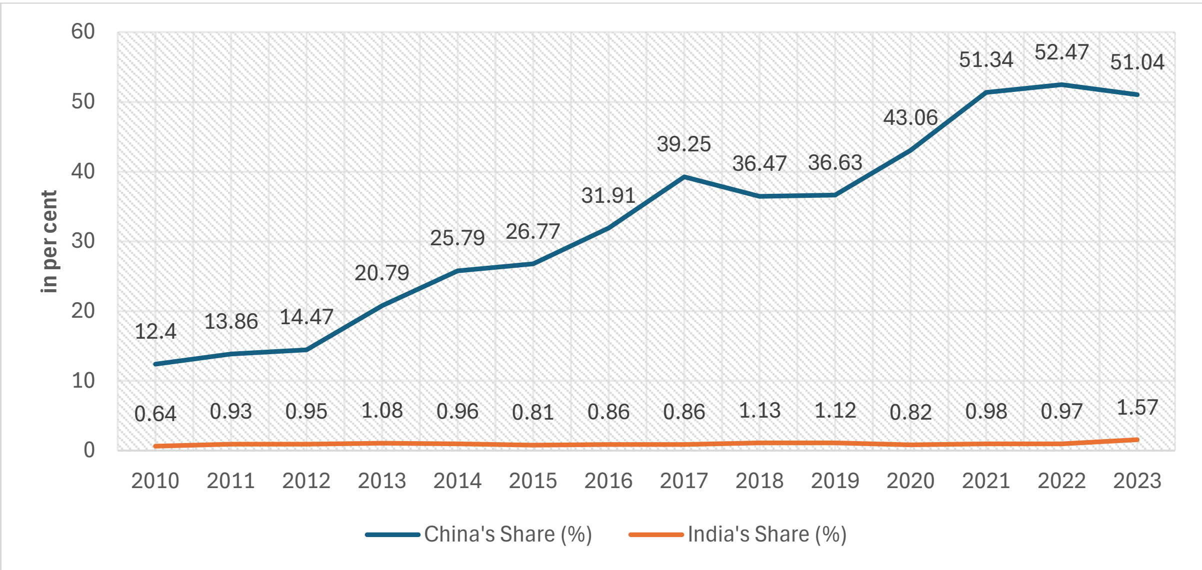

Figure 3: China's share of the world's annual installations in industrial robots

Source: International Federation of Robotics (2024)

(Figure 3 about here)

From 2010 to 2023, the ratio of China's annual installations to India's increased from 11:1 to 52:1, reflecting explosive growth in China (from 15,000 units in 2010 to over 290,000 in 2023) compared to India's modest uptick (from ~1,300 to ~5,500 units). As a share of global installations, China's market share surged from 12.4% in 2010 to 51% in 2023, capturing nearly half of the world's market by 2023. In contrast, India's global share hovered below 1% until 2023, reaching just 1.57%—a testament to its peripheral role.

Operational stock amplifies this gap. China's stock-to-India's ratio widened from 19:1 in 2011 to 54:1 in 2023, with China commanding 41% of the global total (over 1.5 million units) versus India's 1.05% (~38,000 units). This disparity highlights China's cumulative investment in automation infrastructure, positioning it as the epicentre of the "Fourth Industrial Revolution," while India's stock remains fragmented and insufficient to transform its manufacturing base.

7.2 Robot Density: Intensity of Use per Worker

Robot density, defined as the number of operational industrial robots per 10,000 manufacturing workers, provides a more refined measure of automation's penetration than raw installation counts, starkly highlighting the divergence between China and India. This metric reveals the extent to which robots are embedded within production processes, indicating whether they function primarily as substitutes for human labour or as complements to it. As illustrated in Figure 4, the trajectories of the two nations have sharply diverged over the period from 2011 to 2023. China's density surged from approximately 45 units to nearly 470, signalling a strategic, policy-driven pivot towards automation. This acceleration, fuelled by initiatives like 'Made in China 2025' and rising wage pressures, was not solely about labour substitution. It represented a concerted effort to sustain export competitiveness, minimise quality inconsistencies, and counter demographic headwinds. Empirical studies link this rising density to significant productivity gains, but also to the localised displacement of low-skilled workers in routine-intensive roles. Consequently, the Chinese workforce is undergoing a reconfiguration: while manufacturing employment in highly automated firms has contracted, demand for robotics technicians and automation engineers has expanded, exacerbating skill polarisation and presenting formidable reskilling challenges amidst an ageing populace.

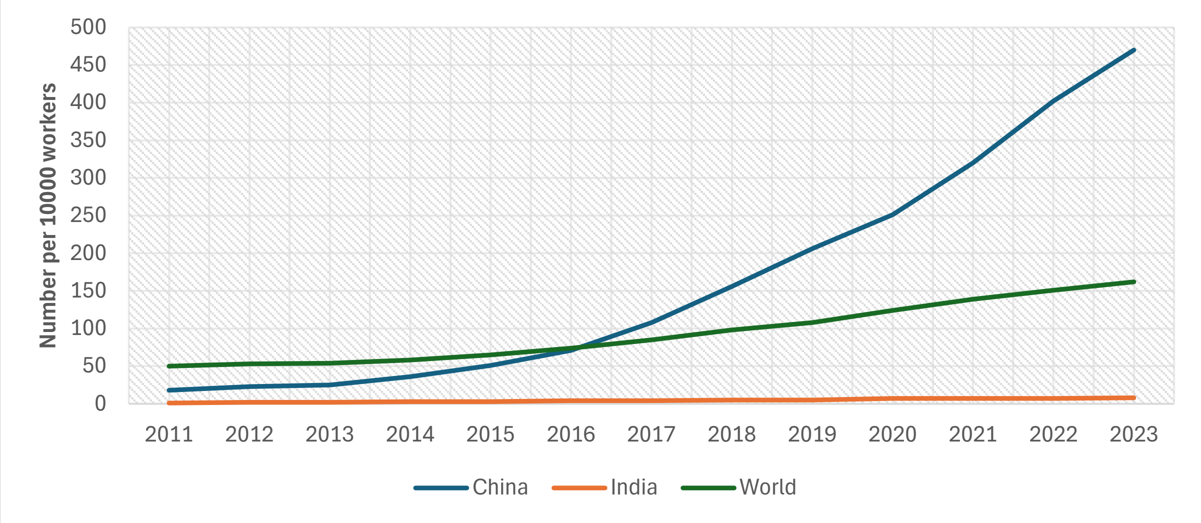

Figure 4: Density of robots in China, India and the World, 2011-2023
Source: International Federation of Robotics (2024)

The implications of this divergence are double-edged. On one hand, India's cautious adoption has preserved employment stability in its manufacturing sector, avoiding the sharper disruptions witnessed in more rapidly automating economies. On the other hand, it risks cementing a significant competitiveness gap. As global value chains increasingly favour highly automated, digitally integrated production bases, firms may bypass India for more technologically advanced locations. Should this adoption lag continue, India could face a future 'replacement shock'—a compressed and disruptive period of adjustment where delayed automation rapidly displaces workers who have not had the benefit of a phased, gradual reskilling process. Mitigating this risk requires proactive and scaled investment in vocational training under initiatives like Skill India, ensuring that a more gradual adoption pathway can still yield both productivity gains and inclusive labour market outcomes.

This macro-level divergence is thrown into even sharper relief within the automotive industry, a traditional pioneer of robotics. See Figure 5. Here, the density metric reveals a widening gulf. Between 2018 and 2023, China's automotive robot density surged from 762 to 987 units per 10,000 employees, a robust compound annual growth rate of 5.3 per cent that significantly outpaced the global average. This trajectory, supercharged by policy and a formidable domestic robotics supply chain, has been further accelerated by the strategic pivot to electric vehicle production. By 2023, China's density in the sector reached 71 per cent of the global benchmark, underpinning its status as the world's leading auto exporter with an output of 30 million vehicles. However, this dominance is not without its vulnerabilities. The expanding density gap over India—which widened from 631 units in 2018 to 833 in 2023—risks deepening supply-chain dependencies and intensifying labour displacement in a sector that employs over five million workers.

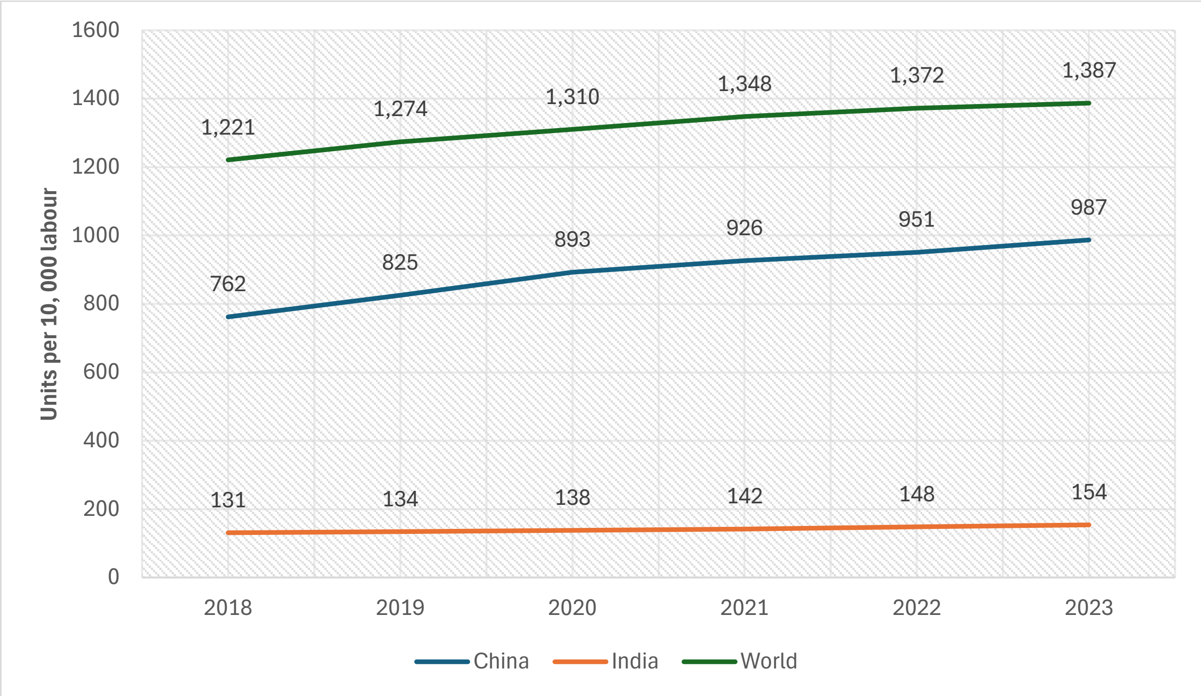

Figure 5: Density of robots in the automotive industry in China, India and the world

Source: International Federation of Robotics (2024)

In stark contrast, India's automotive robot density rose modestly from 131 to 154 units over the same period, a growth rate that translates to just 11% of the global average. This sluggish pace belies underlying structural constraints, including a manufacturing base dominated by small-scale suppliers, elevated integration costs, infrastructural unreliability, and pronounced skill deficits. Despite policy efforts such as the Production Linked Incentive scheme and a surge in installations to 3,551 units in 2023—comprising 42 per cent of India's total robotics adoption—the sector remains in a low-value equilibrium. This approach sustains employment for approximately four million automotive workers, but severely curtails export competitiveness, as evidenced by India's 2023 export volume of 1.5 million vehicles, compared to China's technologically superior output.

Globally, the automotive sector's robot density advanced from 1,221 to 1,387 units between 2018 and 2023, though its growth rate has shown signs of deceleration. This global benchmark, now increasingly pulled upward by East Asian leadership, underscores the sector's pivotal yet uneven role in the broader automation narrative. In conclusion, the divergent density trajectories interrogate the very sustainability of each nation's industrial strategy. China's ascendancy secures its global leadership but raises urgent questions about reskilling and social equity. India's more restrained approach, while protective of employment in the near term, risks perpetuating a cycle of technological lag and diminished global competitiveness. As the sector continues to evolve, effective policy recalibration—fostering indigenous innovation in India and diversifying the supply base in China—will be essential for harnessing the transformative potential of automation while securing inclusive economic outcomes.

7.3 Sectoral Diversity: Breadth of Application

Adoption patterns reveal a stark contrast in robotics integration between China and India, highlighting the different stages of industrial maturity. While both countries are increasing their use of robots, the breadth of deployment varies significantly.

To quantify this, we introduce a Robot Diversity Index (RDI), calculated as $\text{RDI} = 1 - \sum_{i=1}^{N} r_i^2$, where r_i is the proportion of robots in sector *i*. This metric measures deployment breadth: a higher RDI (closer to 1) indicates a more even, diversified distribution across industries, a hallmark of a mature automation ecosystem. A lower RDI signals heavy concentration in a few sectors. China's RDI rose from 0.68 in 2018 to 0.73 in 2023, nearing the global average of 0.74. This reflects robust, widespread adoption across a broad industrial base, including electronics (28% of 2023 installations), automotive (24%), metals (15%), and plastics (10%). This diversification mirrors advanced economies and fuels broad-based industrial upgrading, making China's manufacturing sector more resilient to sector-specific downturns and enhancing its export versatility.

In contrast, India's automation drive remains highly focused. Although its RDI showed notable growth—jumping from 0.52 to 0.66 in 2023—it still lags behind China and the global benchmark. This lower score is driven by a heavy reliance on the automotive sector, which accounts for 42% of installations. Other industries, such as metals, plastics, and chemicals, each hover around just 7%, with minimal penetration in electronics. This high concentration exposes India to sector-specific vulnerabilities and limits the spillover effects of automation technology across its broader economy. The fundamental divergence lies in resilience. China's diversified portfolio allows it to absorb shocks in any single industry, while India's concentrated adoption creates a potential single point of failure. Closing this "diversity gap" is crucial to India's building a more robust, future-proof manufacturing ecosystem.

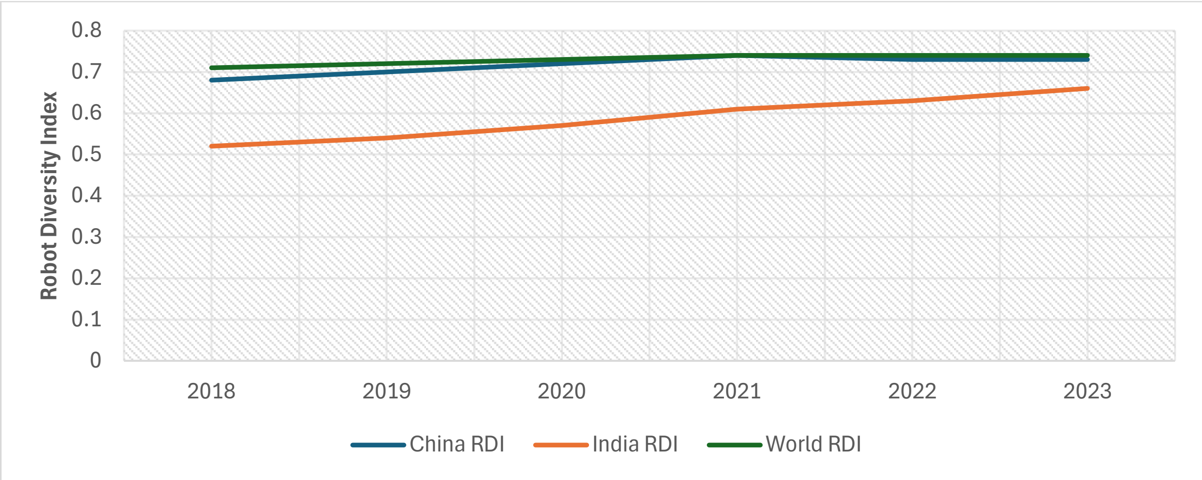

Figure 6: Sectoral Robot Diversity Index, China Vs India, 2018-2023
Source: International Federation of Robotics (2024)

7.4 Task Diversity: Flexibility of Deployment

The contrast between China and India's robotic adoption is further sharpened by analysing the specific tasks that robots perform, revealing a clear evolutionary path. China is advancing towards a more sophisticated and diversified automation ecosystem, while India remains in an earlier, specialised phase. China's task distribution has shown significant maturation over the past decade, marked by a strategic shift away from foundational, heavy-industrial tasks toward more versatile applications. Whilst handling and machine tending now dominate, comprising 56 per cent of installations in 2023, this growth has come at the relative decline of welding, which has fallen from 42 per cent of installations in 2013 to just 18 per cent in 2023. This indicates a diffusion of robotics beyond the automotive assembly line into sectors like electronics and logistics. The steady presence of assembly at 10 per cent further points to the automation of more complex, precision-driven processes.

In contrast, India's automation profile remains heavily specialised and welding-centric, consistent with the dominance of its automotive sector. Welding accounts for 49 per cent of new installations and 48 per cent of the total robot stock in 2023. Handling represents a secondary share of 34 per cent, while more advanced applications, such as packaging and palletising, remain marginal. This suggests that robotics in India is still primarily a tool for enhancing productivity in established processes rather than a platform for transformative operational change.

This divergence is quantified by the Robot Diversity Index by task (RDI_task), which measures the evenness of robot deployment across different functions. See Figure 7. China's RDI task rose from 0.55 to 0.62 between 2018 and 2023, reflecting its successful diversification and alignment with global benchmarks. India's RDI task, while showing impressive growth from 0.48 to 0.62, must be interpreted with caution. Its rapid increase is likely driven by a significant expansion in the volume of handling applications, but its automation base remains fundamentally concentrated on welding for the automotive sector, making it less resilient to shocks in that single industry. The core strategic difference lies in resilience versus specialised efficiency. China is building a versatile automation ecosystem that can adapt to supply chain shifts, whereas India's focus, whilst driving growth in its automotive industry, creates a strategic vulnerability. The next phase of India's industrial growth will therefore depend on its ability to catalyse similar robotic adoption across other tasks and sectors to de-risk its automation strategy.

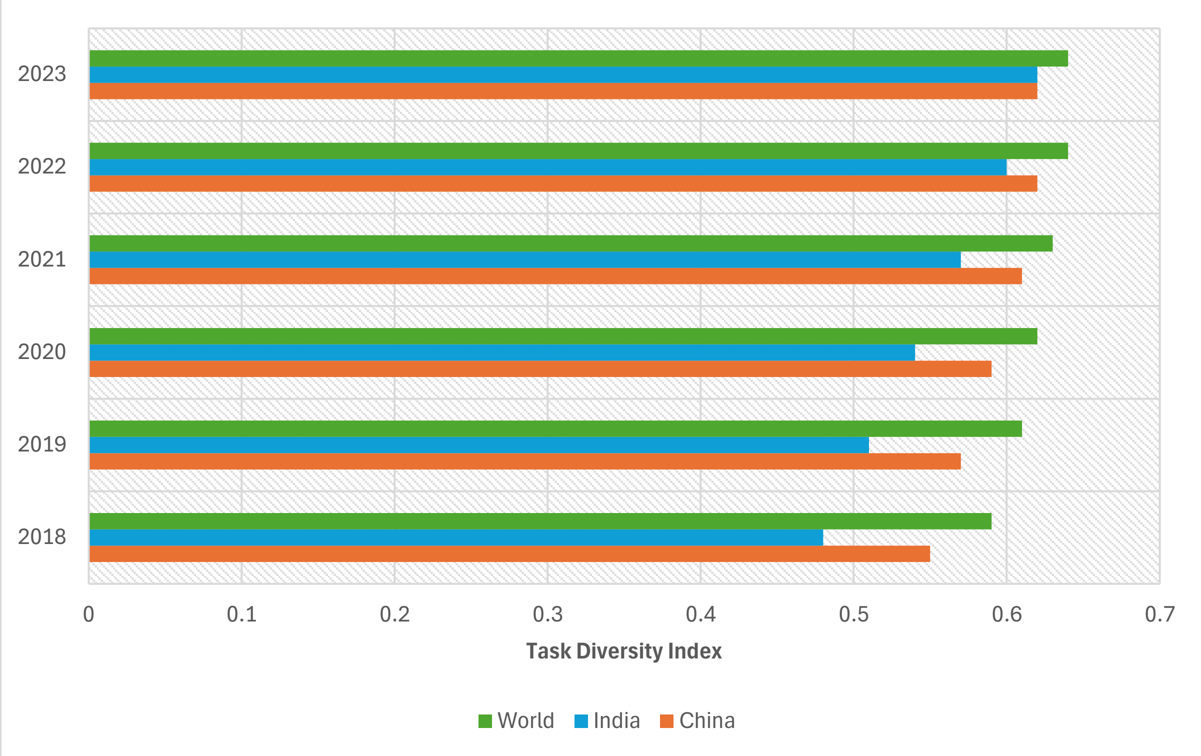

Figure 7: Task Diversity: China vs India, 2018-2023
Source: International Federation of Robotics (2024)

7.5 Import Dependence and Domestic Self-Reliance

Trade dynamics highlight supply-side divergence. China's industrial robot imports (HSN 847950) declined at an annual rate of -3.3% from 2013 to 2024, dropping from $9 billion to $6.4 billion, as domestic production increased. India's imports grew by 14.3% annually, fluctuating between $81 million and $644 million, signalling a heavy reliance on foreign suppliers (e.g., Japan and Germany).

Self-reliance ratios tell a starker story: China's domestic production share jumped from 19.4% in 2018 to 43.2% in 2023, driven by subsidies and Shenzhen's clusters. India's inched from 2.6% to 8.3%, hampered by fragmented R&D and high capital costs. This chasm positions China as a net exporter, insulating it from global disruptions, while India faces forex burdens and technology lock-in.China's ability to scale robot adoption is underpinned by its domestic robotics industry. Local firms such as Estun, CRP, EFORT, JAKA, and DOBOT produce robots at substantially lower costs than imports—often at 60% of the price of Japanese or German equivalents —and humanoid models are available for as little as US$12,000. By 2023, Chinese suppliers accounted for 43% of installations, up from less than 20% in 2018, reflecting both policy support and industry consolidation.

India's domestic market is still in its early stages of development. Companies like TAL Manufacturing Solutions, Addverb, and Systemantics account for only a small portion of the demand. The estimated number of Indian-supplied units increased from approximately 100 in 2018 to about 600 in 2023, which remains well below the overall market size.

Based on the above caveats, Table 1 shows the relative shares of domestically manufactured industrial robots in both countries.

Table 1: Share of domestically manufactured robots in the installed base of industrial robots in China and India

	China – Total articulated robots installed (units)	China – Supplied by Chinese suppliers (units)	Share of domestic suppliers in total installations (%)	India – Total articulated robots installed (units)	India – Supplied by Indian suppliers (estimate, units)	Share of domestic suppliers in total installations (%)
2018	97163	18,835	19.4	3884	100*	2.6
2019	96283	24,980	26	3644	150*	4.1
2020	112208	28,521	25.4	2160	200*	9.3
2021	179900	49,992	27.8	3955	300*	7.6
2022	199017	63,972	32.2	3642	400*	11
2023	200846	86,777	43.2	7218	600*	8.3

Source: Computed from International Federation of Robotics (2024) and Annexure 1

Note: *Estimate of articulated robots supplied by Indian suppliers based on publicly available information. See Annexure 1 for details of how the domestic output for India was arrived at

7.5.1 Import dependence

Both China and India have relied on imports of industrial robots (see Figure 8). However, their trajectories have diverged sharply. Between 2013 and 2024, Chinese imports declined at an average annual rate of –3.3 per cent, while Indian imports increased—albeit with year-to-year fluctuations—at an average annual rate of 14.3 per cent over the same period. This pattern reinforces the earlier inference that the diffusion of industrial robots in China has been supported by the growing availability of competitively priced domestically manufactured robots. As a result, China's dependence on imports has diminished rapidly, underpinned by targeted public policies that simultaneously expanded local production capacity and stimulated domestic demand. By contrast, in India, policy interventions have been less sharply focused, limiting their effectiveness in reducing import reliance and fostering a robust domestic robotics industry. These policy drivers in both countries are analysed in some depth below.

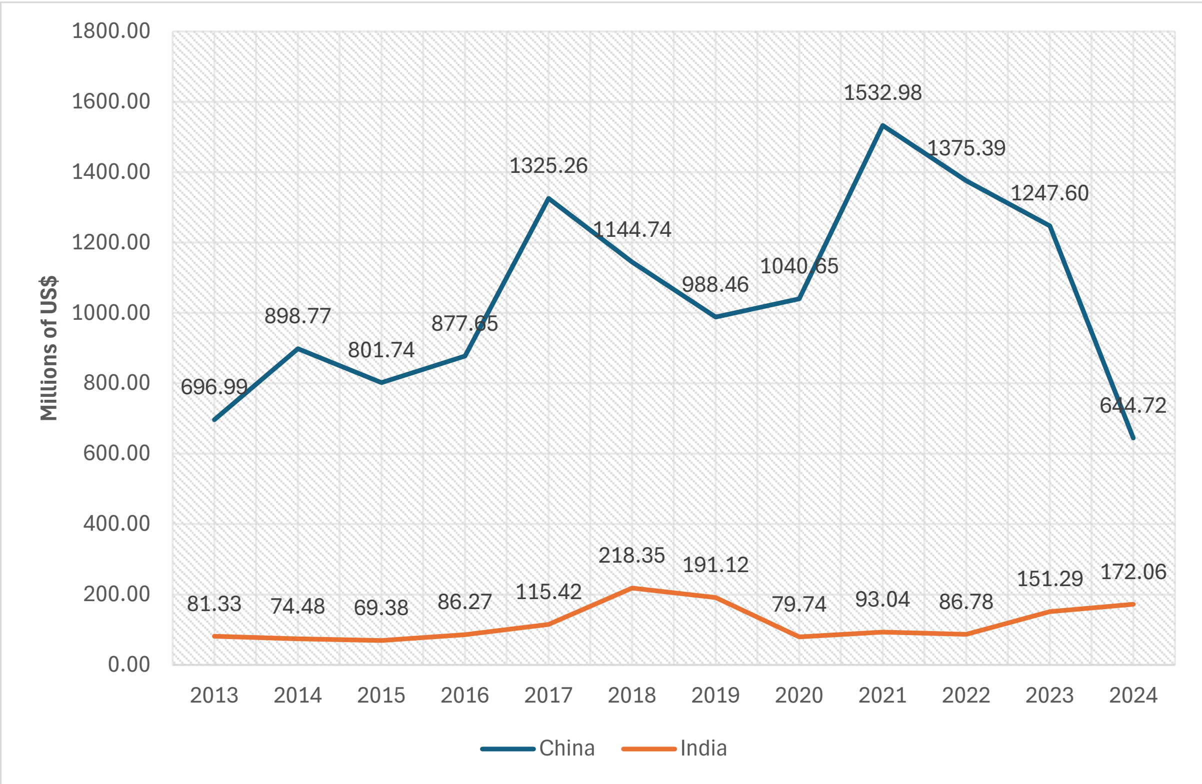

Figure 8: Trends in imports of industrial robots (HSN Code: 847950) to India, 2013-2024

Source: Computed from UN Comtrade

8. Explanation of Divergence

The adoption of industrial automation is driven by a confluence of economic and structural factors, which differ markedly between China and India. These differences can be analysed through three key lenses: labour market pressure, industrial structure, and government policy.

In China, the pressure from the labour market is both strong and urgent. For decades, the country has benefited from a low-cost labour force; however, since the 2010s, wages have been rising at a double-digit annual rate, significantly eroding the cost advantage of labour-intensive manufacturing. Compounding this is a rapidly ageing population, a consequence of the former one-child policy, which is leading to a shrinking working-age cohort and a rising dependency ratio. The result is a powerful economic imperative where substituting expensive and scarce labour with automation is seen not as a choice, but as a necessity. In contrast, India faces weaker and less urgent labour market pressure. While wage growth exists, it is less dramatic and more segmented, held down by a large informal sector and a steady supply of young labour. Furthermore, India is still in its "demographic dividend" phase, with a young median age ensuring a large, young labour force for the foreseeable future. Consequently, the economic logic for replacing this cheap and abundant labour with expensive robots is not yet compelling for the majority of Indian firms.

A second critical factor is the industrial structure and scale of each nation. China, often referred to as the "world's factory," boasts the largest manufacturing sector globally, which is remarkably diverse and increasingly capital-intensive. Its industrial base spans from low-end goods, such as textiles, to high-tech products, including electronics and automobiles. The presence of these large, traditional heavy users of robots creates a natural and powerful demand pull. The sheer scale and complexity of China's industrial base thus provide a huge domestic market for robotic automation. India's manufacturing sector, however, is less dominant globally and more fragmented. While sectors such as automobiles and electronics employ robots, the overall scale and concentration of robot-intensive industries are relatively small. This results in an organic demand for robots that is limited to a few top-tier firms and has not yet become a broad-based trend across the economy.

Finally, the role of activist government policy creates a stark contrast. The Chinese government has made robot adoption a core strategic priority, as exemplified by the "Made in China 2025" policy. This top-down approach is well-funded, with the state providing massive subsidies to both domestic robot manufacturers and end-users, supplemented by additional incentives from provincial and municipal governments. The result is a comprehensive, multi-layered incentive structure that aggressively de-risks and accelerates robot adoption. The Indian government's approach, while aspirational, is less forceful. Initiatives like "Make in India" encourage manufacturing but lack a specific, targeted focus on automation. Schemes such as the Production Linked Incentive (PLI) can indirectly support automation, but there is no central policy equivalent to China's, resulting in a more facilitative role that creates a less powerful push for widespread adoption.

In summary, the interplay of these three factors explains why automation adoption differs so markedly between the two nations.

In China, all three factors are aligned and strong, creating a synergistic push toward automation. In India, the same three factors are weaker and misaligned; the economic drivers are not yet forceful, and policy support lacks the same intensity and focus. This fundamental alignment versus misalignment is why China has become the world's largest robot market, while India's adoption remains nascent and concentrated.

9. Implications of Divergence for China and India

China is the world's largest market for industrial robots, both in terms of annual installations and operational stock. India's adoption, while growing, is significantly lower and slower. This divergence creates distinct sustainability challenges and opportunities for each nation**.** The indicators paint a clear picture: China's robot adoption is characterised by massive scale, high density, diversified applications, and growing self-reliance, enabling it to sustain export competitiveness despite wage pressures (e.g., a 10% annual growth rate since 2010). As Mani's three-factor framework suggests, labor market strains—rising wages and ageing demographics—have forged a "perfect storm" for automation in China, transforming potential vulnerabilities into strengths. India, conversely, grapples with a demographic dividend that delays urgency: the abundance of young labour and slower wage hikes weaken the economic case for robots, resulting in low-intensity, concentrated use.

This divergence poses policy challenges. For India, fostering robot ecosystems through incentives (e.g., PLI schemes) and skilling could harness its potential without displacing jobs prematurely. China's model warns of over-reliance on state-driven scale, risking inequality if reskilling lags. Ultimately, as global value chains fragment, bridging this gap will determine which nation leads the automated future.

The increase in robot adoption carries both economic and environmental implications. Economically, the most immediate and pronounced effect is on export competitiveness, particularly for China, which is relatively more export-oriented than India. We first examine the impact of automation on China's exports before turning to the other economic and environmental consequences.

9.1 Maintenance of export competitiveness in China

China's ability to maintain, and even expand, its global export share in labour-intensive products—despite manufacturing wages rising by an average of 7-10% annually since 2015—stems primarily from the aggressive adoption of industrial robots, which offset escalating labour costs by boosting productivity and efficiency. As wages have climbed from around USD 400/month in coastal hubs in 2015 to over USD 800 by 2024, traditional low-cost labour advantages have eroded, prompting a shift toward automation as a core strategy for cost containment. This "automation offset" is particularly evident in small manufactured goods, where robots handle repetitive, low-skilled tasks such as assembly and packaging, allowing firms to sustain slim margins in global markets. For instance, between 2019 and 2023, China added approximately 280,000 industrial robots annually, accounting for over 50% of global installations, which enabled factories to boost output without proportionate wage hikes. This has directly translated to export gains: trade data from Harvard's Growth Lab shows China's share of global exports in labour-intensive categories surged, with small goods like brooms, mops, and pens rising 9 percentage points to 52.3%; furniture gaining 1.5 points; and toys increasing from 54.3% to 56.9%.

A pivotal enabler is China's cultivation of a domestic robot industry, which has slashed acquisition costs by 30-50% compared to imports, democratising automation for small and medium-sized enterprises (SMEs) that dominate labour-intensive exports. Policies like "Made in China 2025" have subsidised local producers (e.g., Siasun and Estun), fostering a self-reliant ecosystem where over 70% of installed robots are now homegrown by 2025. For SMEs in sectors such as toys and furniture—previously vulnerable to wage pressures—these affordable robots (costing USD 20,000-30,000, compared to USD 50,000+ for foreign models) reduce unit labour costs by 20-40%, thereby preserving price competitiveness against rivals in Vietnam or Bangladesh. Empirical studies corroborate this: rising minimum wages have spurred the uptake of robots in routine- and labour-intensive firms, with a 10% wage increase linked to a 5-7% higher robot density, directly correlating with stable or growing export volumes.

This resilience extends beyond cost savings to productivity multipliers, where robots enable 24/7 operations and precision in high-volume, low-margin goods, amplifying China's scale advantages in global value chains. While automation has displaced some low-skill jobs (e.g., a net 1-2% employment dip in affected sectors), it has spurred upstream demand for parts and logistics, sustaining overall export momentum—evidenced by China's labour-intensive exports reaching USD 1.2 trillion in 2024, up 8% YoY. In essence, by leveraging state-backed, low-cost robotics, China has transformed wage hikes from a liability into an impetus for technological upgrading, securing its dominance in labour-intensive trade even as competitors chase its former low-cost model.

9.2 Other economic implications for both China and India

In China, increased automation presents both opportunities and challenges. On the positive side, it helps maintain global competitiveness by enabling the country to offset rising labour costs and retain its position as the "world's factory." Automation also allows for the production of higher-value, more complex goods, such as electric vehicles and electronics, thereby securing China's economic future. However, these gains come with significant drawbacks. The rapid push for automation necessitates enormous capital investment and creates a dependency on a limited number of domestic and international robotics suppliers, introducing potential supply chain vulnerabilities. Furthermore, the economy faces the risk of a skills mismatch, as low- to medium-skilled workers may be displaced faster than the education system can produce the robotics technicians, engineers, and data analysts required to manage and maintain the new systems, raising the possibility of structural unemployment.

In India, automation has different implications. Notably, the country can use its large and youthful population as a key advantage, especially in labour-intensive sectors like textiles, leather, and certain assembly activities, providing vital employment and supporting social stability. On the downside, however, the slow pace of automation increases the risk of "premature deindustrialisation" (Nagaraj, 2025). If Indian manufacturing remains globally uncompetitive due to low productivity, it may not grow enough to absorb the increasing workforce, and companies might instead automate in other countries or relocate advanced manufacturing operations abroad, bypassing India entirely. Additionally, slower adoption of robotics could cause India to miss vital opportunities in high-value, inherently automated industries such as advanced electronics and semiconductor manufacturing, limiting the country's ability to ascend the global industrial ladder.

9.2.1 Environmental sustainability

In China, the high rate of robot adoption has both environmental benefits and challenges. On the positive side, automation offers the potential for higher eco-efficiency. Robots can optimise material usage through precise cutting and reduced waste, improve energy efficiency in manufacturing processes, and enable the production of higher-quality goods with longer lifespans. Modern automated factories often incorporate advanced environmental management systems, with robots playing a central role in these improvements. However, these gains may be offset by the "rebound effect." Efficiency improvements can lower production costs, potentially driving a significant increase in overall output and consumption, which could offset per-unit environmental benefits and lead to increased resource extraction, energy use, and waste generation. The environmental footprint of manufacturing the robots themselves and powering the data centres that control them further adds to the overall load. Additionally, the rapid adoption cycle creates a future stream of electronic waste from decommissioned robots, posing significant challenges for the responsible disposal and recycling of these devices.

In India, where adoption of industrial robots is slower, the environmental implications differ. On the positive side, slower automation temporarily avoids the immediate surge in consumption and waste that can accompany the rapid, large-scale deployment of robots. Nevertheless, significant environmental challenges persist. A large portion of India's manufacturing remains informal or relies on outdated, less efficient technologies, resulting in higher pollution, greater energy consumption per unit of output, and increased material waste compared to modern automated facilities. The slow pace of automation also delays the transition to greener manufacturing practices, leaving the country with "dirty" inefficiency that undermines environmental sustainability.

9.2.2 Social Sustainability

In China, the rapid adoption of robots presents significant social challenges. One major concern is the aggravation of inequality and social strain. The displacement of millions of factory workers, particularly older and less-educated migrant workers who lack the skills to transition into service or technology sectors, could generate considerable social upheaval. This process risks exacerbating the urban-rural income divide and heightening social tensions. At the same time, demographic pressures compound the issue: China's ageing population makes automation a necessity, yet the swift pace of technological transition leaves little time to reskill the workforce in a socially manageable way, intensifying potential social disruption.

In India, slower automation has different social implications. On the positive side, by preserving more labour-intensive jobs, India can promote broader economic inclusion, reduce poverty, and maintain social stability—an especially important goal for a developing democracy. However, there are notable drawbacks. The looming threat of automation may be used to suppress wage growth and resist improvements in working conditions, as the constant spectre of replacement by machines undermines labour's bargaining power. Furthermore, the benefits of high-tech, automated sectors are likely to accrue primarily to a small, highly skilled elite, while the majority of workers remain in low-productivity jobs. This divergence risks creating a deeply bifurcated society and economy, with a growing digital divide between those who can access and benefit from advanced technologies and those who cannot.

Table 2 summarises these three implications of robot adoption in China and India.

Table 2: Implications of Divergent Robot Adoption in China and India

Dimension	Implications for China	Implications for India
Economic	Sustains export competitiveness and fosters the production of higher-value goods; however, it also risks high capital investment and supply-chain dependencies.	Preserves low-cost labour advantage but risks premature deindustrialisation and missed opportunities in high-value, automated industries.
Environmental	Enables higher eco-efficiency (less waste, better energy use) but faces rebound effects from increased output and e-waste from rapid upgrade cycles.	Avoids immediate automation-related e-waste, but perpetuates "dirty" inefficiency from outdated, polluting manufacturing technologies.
Social	Leads to significant workforce displacement and skill polarisation, aggravating inequality and social strain amidst an ageing population.	Promotes broader economic inclusion by preserving jobs, but risks a bifurcated economy and suppressed wage growth due to the threat of automation.

The divergence in robot adoption between China and India highlights a fundamental tension in sustainable development. China is prioritising economic and environmental efficiency, potentially at the cost of social stability in the short to medium term. Its approach represents a high-risk, high-reward bet on a technology-dominated future, seeking rapid gains in productivity and competitiveness. By contrast, India is prioritising social stability and employment, even if this comes at the expense of long-term economic competitiveness and environmental upgrading. Its model reflects a more cautious approach, aimed at avoiding immediate social disruption and preserving broad-based livelihoods.

The most sustainable path is likely not at either extreme, but in a managed transition that balances these competing concerns. For China, this would entail implementing large-scale, proactive reskilling programmes and strengthening social safety nets to mitigate the human costs of rapid automation. For India, a strategic approach would involve automating key sectors to enhance competitiveness, while simultaneously investing in education and skills development to prepare its workforce for future jobs, rather than focusing solely on today's employment needs. Such a balanced strategy could enable both countries to pursue sustainable development that integrates economic, environmental, and social objectives.

The robot adoption gap is therefore a clear lens through which to view the different developmental challenges and choices facing the world's two most populous nations.

10. Conclusions

In conclusion, the divergent paths of robotics adoption in China and India illuminate a fundamental trade-off at the heart of modern industrial development. China's model, characterised by strategic state intervention and rapid technological assimilation, has successfully transformed automation into a tool for sustaining global economic leadership, albeit at the cost of significant social and adaptive challenges. India's more cautious, market-led approach has prioritised employment stability but risks entrenching a low-productivity equilibrium that could marginalise its manufacturing sector in an increasingly automated global economy. The central policy imperative for China is to manage the social fallout of its technological leap through robust reskilling and social safety nets. For India, the challenge is to strategically catalyse automation in key sectors without forsaking its demographic advantage. Ultimately, the future competitiveness of both nations will hinge on their ability to forge a more balanced pathway—one that harnesses the transformative power of robotics while ensuring that the benefits of technological progress are shared broadly and inclusively.

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References

Acemoglu, D., & Restrepo, P. (2020). Robots and jobs: Evidence from US labour markets. *Journal of Political Economy, 128*(6), 2188–2244. https://doi.org/10.1086/705716

Cheng, H., Jia, R., Li, D., & Li, H. (2019). The rise of robots in China. *Journal of Economic Perspectives*, 33(2), 71–88. https://doi.org/10.1257/jep.33.2.71

Financial Times. (2025, January). Homegrown robots help drive China's global export surge. https://www.ft.com/content/cf427f83-89b2-4912-8f79-0f367ab6e553

Graetz, G., & Michaels, G. (2018). Robots at work. *The Review of Economics and Statistics, 100*(5), 753–768. https://doi.org/10.1162/rest_a_00754

International Federation of Robotics. (2024). *World Robotics 2024*. IFR.

Mani, S. (2024). The impact of new technology on employment in India's manufacturing industry: Examining the diffusion of multi-purpose industrial robots. *The Indian Journal of Labour Economics, 68*(2), 473–492. https://doi.org/10.1007/s41027-024-00525-1

Nagaraj, R (2025), 'India's premature deindustrialisation and Falling investment rate in the 2010s', *World Development*, 191, https://doi.org/10.1016/j.worlddev.2025.106954