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NITI Aayog

NITI Frontier Tech Hub

AI for Viksit Bharat:
The Opportunity for Accelerated Economic Growth

September 2025

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A special word of thanks is extended to McKinsey & Company for its exemplary partnership in providing analysis & insights that helped us to develop a roadmap that is implementable, impact-driven, and aligned with India's long-term vision.

Together, the collective wisdom and collaboration of all partners have made this effort possible.

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Foreword

If India is to accelerate its growth to the 8% annual rate required for the realization of Viksit Bharat, we have no option but to significantly raise productivity across the economy and unlock new growth through innovation. Artificial Intelligence can be the decisive lever. This report sets out a practical roadmap on how we can harness AI to translate this potential into outcomes.

The analysis highlights two major AI unlocks. First, accelerating adoption of AI across industries to enhance productivity and efficiency-bridging nearly 30-35% of the required step-up. Second, transforming R&D, especially through generative AI, which can enable India to leapfrog into innovation-driven global opportunities, contributing at least 20-30% of the required uplift.

With a focused and sector-specific approach, industries such as banking and manufacturing can deploy AI today to improve efficiency, service quality, and competitiveness-creating momentum for deeper transformation. At the same time, India must nurture frontier innovation, from AI-enabled drug discovery to software-defined vehicles, building the next engines of growth.

The path to 8% growth runs through decisive AI adoption and innovation. This report offers a roadmap to guide that journey. I invite government, industry, and academia to move forward with urgency and collective purpose.

BVR Subrahmanyam
CEO, NITI Aayog

Foreword

The NITI Frontier Tech Hub's AI roadmap for Viksit Bharat sends an unequivocal signal: India's mission to sustained 8%+ growth is anchored in bold, pervasive AI integration and tireless innovation—and must become a core national priority. This transformation journey leverages sector-focused strategies and frontier technology ecosystems, positioning India to lead the global race in inclusive, responsible AI deployment and governance.

Our deep gratitude is due to the Expert Council for its strategic foresight and instrumental contributions, and to McKinsey for its exemplary partnership in shaping a roadmap that is implementable and impact-driven.

The time for India to lead the AI revolution at scale is now. With robust policy frameworks, advanced infrastructure, and collaborative innovation, India can pioneer a new model of growth and societal advancement, ensuring prosperity, resilience, and technological leadership for decades to come.

The NITI Frontier Tech Hub will continue to activate this agenda, galvanizing experts, states, and industry toward shared progress—securing the foundations for an AI-powered Viksit Bharat

Debjani Ghosh
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CHAPTER 1: INTRODUCTION

Over the next decade, the adoption of Artificial Intelligence (AI) across sectors is expected to add $17–26T[1] to the global economy. India's combination of a large STEM workforce, expanding R&D ecosystem, and growing digital and technology capabilities positions the country to participate in this transformation, with the potential to capture 10–15% of global AI value.[1]

Placed against India's economic outlook, this potential becomes more significant. At its current growth rate of 5.7%, India's GDP is projected to reach $6.6T by 2035. However, under the aspirational 8% growth trajectory outlined in the government's vision for the nation known as Viksit Bharat, India's GDP could increase to $8.3T, representing an incremental $1.7T compared with the current growth path (Exhibit 1)

AI opportunities for India

Potential AI opportunities for India are presently spread across three levers:

1. **Accelerating AI adoption across industries to improve productivity and efficiency, potentially bridging 30–35% of the gap:** Higher output, lower costs of goods and services, and improved access for underserved markets. These effects are expected to materialize across both domestic consumption and export markets

2. **Transforming R&D, through generative AI, could help India leapfrog into innovation-driven global opportunities, bridging a minimum 20–30% of the gap:** Can generate new AI-led market opportunities within traditional industries, support commercialization, reshape legacy value chains, and strengthen long-term competitiveness

3. **Innovation in technology services, strengthening India's reputation as a technology services leader, contributing another 15-20% to the step up:** Could drive the development of higher-value solutions and new business models, enhancing India's competitiveness in the global market

This roadmap focuses on the first two levers, while a separate publication addresses the third—innovation in technology services.

This roadmap is the first version of this perspective. The insights and recommendations in this report will be periodically revised, to reflect evolution of the technology as well as the global economic context. This will keep India's strategy for accelerated economic development relevant, resilient and future-ready.

1 McKinsey report titled "The Economic Potential of Generative AI: The Next Productivity Frontier". June 2023.

Exhibit 1

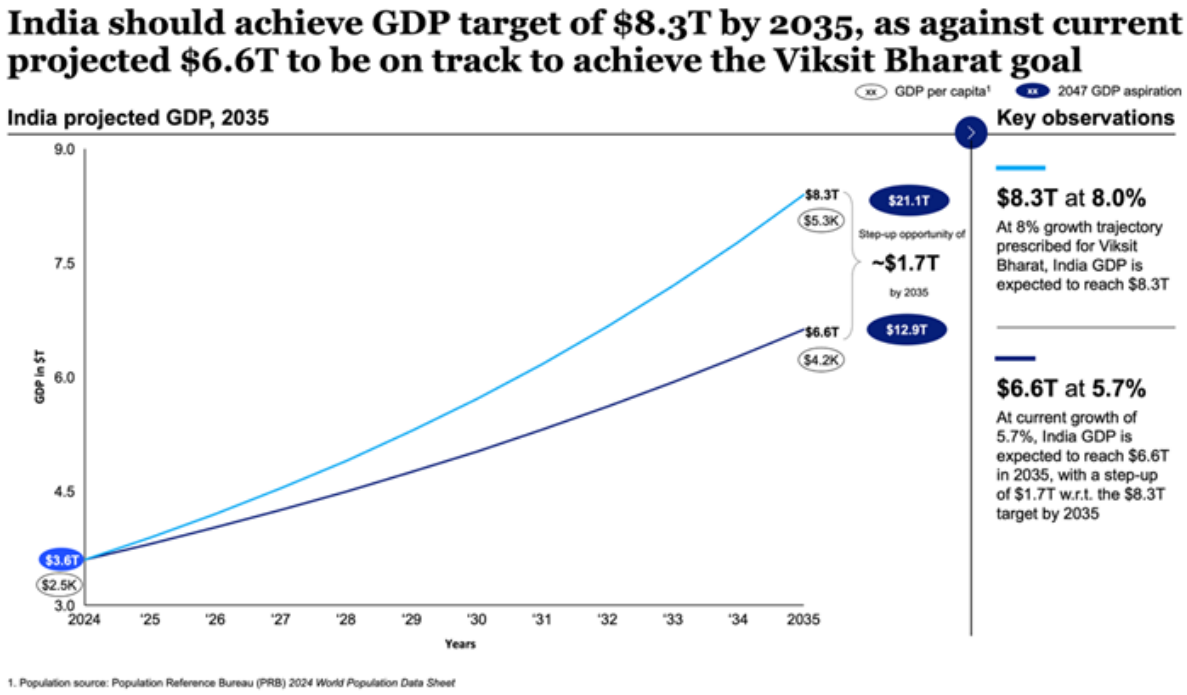
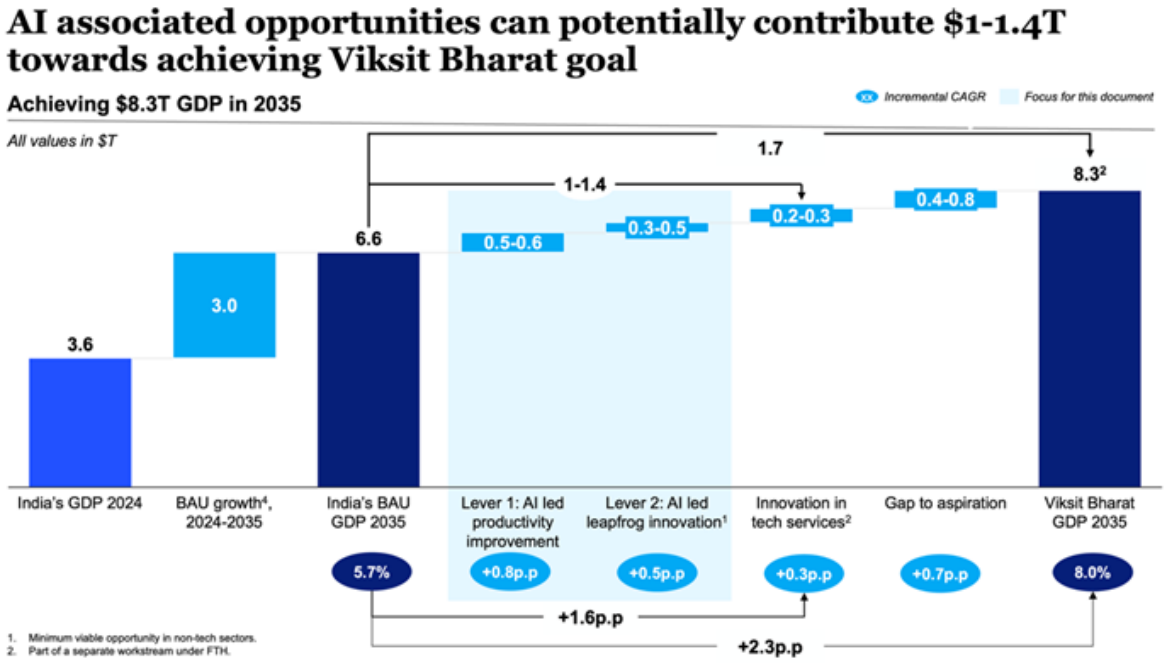


Exhibit 2



Strategic enablers for AI-led value creation

Realizing the potential of AI in India depends on establishing strategic enablers across infrastructure, governance, industry, and workforce development. Effective collaboration between government, the private sector, and academia can support responsible deployment,

scaling, and skill development, while ensuring broad access and alignment with national priorities.

- Access to critical AI infrastructure such as cloud platforms, compute, and foundational datasets could help strengthen India's sovereign AI capabilities. At the same time, robust AI governance frameworks, including ethics guidelines and risk controls, could ensure responsible and secure deployment.
- The private sector can lead the scaling of AI adoption by embedding AI into core industry processes. This includes driving model validation, secure deployment, and AI-powered decision-making, while maintaining resilience and accountability at leadership levels. Reskilling senior executives and upskilling the broader workforce would be key to enabling this transformation.
- Academia can be vital in anchoring research and supporting large-scale workforce transformation. The creation of AI testing sandboxes can further enable safety and scale.
- To ensure inclusive growth, it is essential to provide equitable access to AI resources and opportunities, particularly for MSMEs and economically underrepresented regions.

These enablers can be potentially mapped into a phased possible path forward, covering short-, medium-, and long-term priorities aligned with India's 2035 goals. Progress could be tracked against established KPIs, with relevant baselines.

India is at a pivotal point in its AI journey. It can capture a meaningful share of AI-driven value by leveraging its strengths and implementing key enablers. The following chapters explore the industries, business models, and approaches that could support this transformation.

CHAPTER 2: POTENTIAL OUTCOMES FOR AI-LED VALUE CREATION

AI remains in its formative stage, and market structures are still evolving. To secure a leading position globally, India could consider investing in sovereign infrastructure, including energy, to build resilience and unlock higher value-creation potential.

The India AI Mission, with an estimated budget of over ₹10,000 Cr for five years, represents a foundational step toward strengthening national AI capabilities by focusing on data, talent, and adoption. Built on seven core pillars, the mission plans to deploy 38,000+ GPUs[2] through a federated compute network, develop India-specific large language models, and establish an anonymized, consent-based public dataset platform, placing data at the center as a key enabler for innovation, scalability, and governance in a diverse, multilingual nation. The initiative also aims to expand AI skilling through the integration of AI courses at multiple academic levels and creation of AI/Data Labs across Tier 2 and Tier 3 cities, while accelerating adoption through application development in critical sectors such as agriculture, healthcare, education, and mobility.

2 Press Information Bureau (PIB), Government of India. "Cabinet approves IndiaAI Mission – a significant step towards boosting India's AI ecosystem." March 7, 2024.

While these measures would help lay the groundwork for robust infrastructure, it is also important that talent pipelines, sectoral uptake, sustained execution, and ecosystem alignment are in place to realize India's AI potential. In the following section, the report identifies potential outcomes that could contribute to the AI-led GDP growth by 2035.

Potential Outcome 1: India becomes the data capital of the world

One of India's biggest strengths is its data, and it has the potential to leverage this advantage. In the digital economy, data will function as currency that powers innovation, drives valuations, and shapes global leadership. India has the potential to lead due to its scale, diversity and digital infrastructure. By placing quality, trusted, and interoperable data at the core, India could become the data capital of the world and set new global benchmarks for breadth, depth, and quality of trusted data ecosystems, potentially through the following options:

- Creating an anonymized data collection framework to easily and safely collect public data led by entities such as India Data Management Office (IDMO) and National Data Access Platform
- Building a marketplace of certified non-personalized data with privacy tags and quality certificate features supported by the National Data Governance Framework
- Developing specialized data platforms for specific sectors as follows:
    - → **Financial services:** Enabling access to cross-industry, alternative data sources with the IDMO standardizing access and ensuring borrowers retain the right to opt out
    - → **Manufacturing:** Establishing an open "Manufacturing Data Grid" for OEMs, suppliers, and startups to trade production and supply-chain data through standard APIs
    - → **Pharmaceuticals:** Building a unified national omics dataset by sequencing over 10M genomes by 2035 to fuel AI in drug discovery
    - → **Automotive:** Enabling OEMs to share anonymized telemetry data to create a large-scale sensor dataset for safety and innovation

AI Kosh, owned and operated by the Government of India under the India AI Mission, hosts over 350 curated, non-personal datasets such as census data, Indian language resources, and satellite imagery.[3] While this is a good foundation, scaling the breadth and depth of data could position it to move into high-value domains such as genomics, manufacturing telemetry, and cross-sector financial data, implying that datasets are certified for quality, tagged for privacy, and interoperable. This can potentially transform AI Kosh from a foundational national repository into a most trusted and innovation-ready data platform. India could consider the following options:

- Setting up sector-specific data infrastructure (e.g., for the financial sector) that is integrated with AI Kosh to host regulatory-grade datasets for model building and supervision.
- Publishing institution-level AI inventories and publishing a sector-wide AI repository

3 IndiaAI Mission article titled "Now Open: Expression of Interest (EOI) to Contribute Datasets and AI-Artefacts to AIKosh". July 7, 2025

(metadata only) to provide supervisory visibility as AI scales across sectors.

- Integrating AI with Digital Public Infrastructure (DPI) to accelerate inclusive, affordable financial services at scale (e.g., voice access, Account Aggregator flows, fraud controls).

Potential Outcome 2: India supports the development of an adaptable and efficient AI-skilling ecosystem

By 2035, India can work towards narrowing the AI skill gap with leading countries by developing skilled professionals, advancing research, and contributing to AI models. The focus can be on measuring outcomes of research impact basis international peer-reviewed publications, the number of PhDs focused on AI research, practical expertise and original AI contributions based on patents filed. India could consider the following options:

- **Harnessing academia better:** AI Chairs across the top 20 technology, medical, law, and business schools to promote and create PhDs/senior qualifications at the intersection of subject matter expertise and AI
- **Incentivizing industry:** Finding ways to upskill 3–5% of working professionals through AI-first modules, supported by tax deductions on employer spending
- **Upskilling India:** An AI Open University (both physical and online) could enhance Skill India Digital/eShram in partnership with private ed-tech platforms for the public
- **Equipping professionals:** Specialized skilling across sectors, illustrated below through two key examples:
  - → **Financial services:** Launch a national certification program in AI for Credit, Risk and Fraud, co-designed with top universities
  - → **Manufacturing:** Initiate a tiered "AI for Advanced Manufacturing" credential in collaboration with industry leaders
- **Exploring AI governance literacy:** Look at how to educate Boards and C-suite of regulated financial entities covering accountability, risk management, deployment models (e.g., human-in-the-loop), documentation, and disclosures.
- **Ensuring oversight:** Consider how a new supervisor entity could help to build capacity in AI oversight, model risk, audits, and sector risk intelligence.

Potential Outcome 3: Targeted AI adoption unlocks sectoral growth

Focusing on AI enablers across the manufacturing, financial services, pharmaceuticals, and automotive industries—which represent roughly 25% of India's projected 2035 GDP—can help translate AI adoption into measurable outcomes by supporting innovation, improving productivity, and enhancing export potential. A sectoral analysis highlights these areas as potential candidates for AI-led innovation and accelerated growth (Exhibit 4).

- **Manufacturing:** Building world-class smart-factory corridors could enable AI growth unlocks by: (1) Designating AI-ready industrial parks that co-locate clean-energy plants with high-performance-computing labs and robotics test zones; (2) Launching an open manufacturing data grid so OEMs, suppliers and start-ups can exchange real-time production data via standard APIs; and (3) Rolling out a tiered "AI for advanced

manufacturing" credential to up-skill engineers from micro-learning to postgraduate level.

- **Financial services:** Unlocking responsible AI at scale by: (1) Scaling-up sandbox pilots to pressure-test explainable credit, fraud-risk and anti-money-laundering models; (2) Introducing or enhancing existing frameworks to share alternative, consent-based datasets; and (3) Certifying specialists through a national "AI for Financial Services" program, creating a trusted talent bench for financial institutions.
- **Pharmaceuticals:** AI could unlock growth by compressing drug-discovery timelines and investments by: (1) Expanding biotech parks by 10x and adding best-in-class, high-performance computing to power AI modelling; (2) Creating a unified national omics dataset with tiered researcher access; and (3) Training over 100k biopharma R&D scientists in computational biology and AI by 2035.
- **Automotive:** Leapfrog to software-led, autonomous mobility by: (1) Setting up six to eight physical-digital testing parks for India-specific autonomous-vehicle validation; (2) Deploying 10,000 km of 5G/early-6G "smart corridors" for real-time vehicle-to-infrastructure data flow; and (3) Mandating anonymized telemetry from 20–25% of new vehicles each year to seed national safety and innovation datasets.

This analysis could be applied to construction, wholesale and retail trade, and professional services, contributing another 25% of the projected 2035 GDP and ensuring AI-driven value scales across the economy (Exhibit 4).

Potential Outcome 4: India's jobs are future-proofed, and industry transformed at scale

India can address fragmented skilling through a unified system that enables continuous worker upskilling, accelerates firm-level digital adoption, and strengthens safety nets. This would mean mapping job shifts annually, embedding lifelong learning into career pathways, scaling MSME digital upskilling, and protecting gig and platform workers – projected to reach about 23.5M by 2029–30[4]. International benchmarks highlight both the urgency and the opportunity: the World Economic Forum estimates 23–25% of roles will change within five years (69M created; 83M disrupted)[5], the OECD finds 27% of jobs are in occupations at high risk of automation[6], the U.S. may see 12M occupational transitions by 2030 as generative AI scales[7], and earlier global studies suggest China could face up to ~100M such transitions under fast automation scenarios[8]. India could consider the following options:

4 NITI Aayog policy brief titled "India's Booming Gig and Platform Economy: Perspectives and Recommendations on the Future of Work". June 2022

5 Future of Jobs Report 2023 titled "Future of Jobs Report 2023: Up to a Quarter of Jobs Expected to Change in Next Five Years". April 30, 2023.

6 OECD report titled "OECD Employment Outlook 2023: Artificial Intelligence and the Labour Market", finding that approximately 27% of jobs across OECD countries are in occupations at high risk of automation (including AI). July 2023

7 McKinsey Global Institute report titled "Generative AI and the future of work in America". July 26, 2023.

8 CSIS ChinaPower Project analysis titled "Is China Ready for Intelligent Automation?" August 25, 2020

- **Continuous reskilling:** Developing job transformation maps for 25-30 priority sectors can help to identify task shifts, emerging roles, and reskilling pathways, drawing on models such as "Workforce Singapore"[9]. Large enterprises could prepare and submit firm-level skilling plans.
- **Accessible learning:** One approach could be introducing digital, portable individual learning accounts. Singapore's "SkillsFuture"[10] and the UK's "Lifelong Learning Entitlement"[11] offer interesting models to consider. These accounts could be designed to link credit reimbursements to verified course completion and employment outcomes.
- **Industry-wide AI adoption:** By preparing industry AI plans, with curated toolkits, vetted vendor lists, and sector-specific micro-credentials. Consider Singapore's "Industry Transformation Map" framework as a reference[12].
- **Supporting gig and platform workers:** By implementing the Code on Social Security (2020)[13], ensuring universal registration and benefits such as health insurance, accident cover, and retirement savings that can be carried between jobs. Consider using the e-Shram portal to manage benefits and pilot wage-loss insurance schemes for workers facing job loss.
- **Supporting at-risk worker groups, a live, integrated skills and jobs database** by linking e-Shram, Skill India Digital, and public job listings into a constantly updated system that tracks in-demand skills, identifies at-risk worker groups, and connects them directly to funded training and verified job opportunities.
- **Financial consumer and worker AI literacy.** Ensuring disclosures and grievance pathways into adoption programs so that trust leads to usage.

Guided by these potential outcomes, the report proceeds to examine two primary AI opportunity levers for India: Lever 1 focuses on accelerating AI adoption across industries to enhance productivity and efficiency, while Lever 2 explores the transformation of R&D through generative AI, enabling India to capture innovation-driven opportunities and bridge a significant portion of the growth gap.

9 Workforce Singapore website
10 SkillsFuture Singapore ("SSG") government website
11 House of Commons Library research briefing titled "The Lifelong Learning Entitlement." Published 12 March 2024.
12 Singapore Ministry of Trade and Industry webpage titled "Overview" (Industry Transformation Maps under the S$4.5 billion Industry Transformation Programme). Last updated September 8, 2025
13 Gazette of India (Extraordinary), titled "The Code on Social Security, 2020 (No. 36 of 2020)". 28 September 2020.

CHAPTER 3: LEVER 1 - ACCELERATING AI ADOPTION ACROSS INDUSTRIES TO IMPROVE PRODUCTIVITY AND EFFICIENCY

To assess AI's potential for India, a detailed analysis was conducted on its ability to enhance productivity across industries. The study covered over 850 occupations across 16 sectors and examined more than 2,100 distinct work activities. The analysis indicates that AI adoption could contribute an additional $500–600B to India's GDP by 2035, beyond the projected growth trajectory, driven by productivity improvements, operational efficiencies, and the reallocation of human effort to higher-value tasks.

The following sections detail the methodology and findings behind these projections.

Approach

Specific adoption scenario models were considered (i.e., the pace at which industry adopts the technology at scale, resulting in impact on productivity)—early, midpoint, and late—to estimate when AI could effectively take on these activities based on currently demonstrated technologies and their expected development in the future and country-specific factors such as wage levels and occupational mix. The model incorporates software capabilities such as machine learning, data analytics and hardware-driven automation such as robotics.

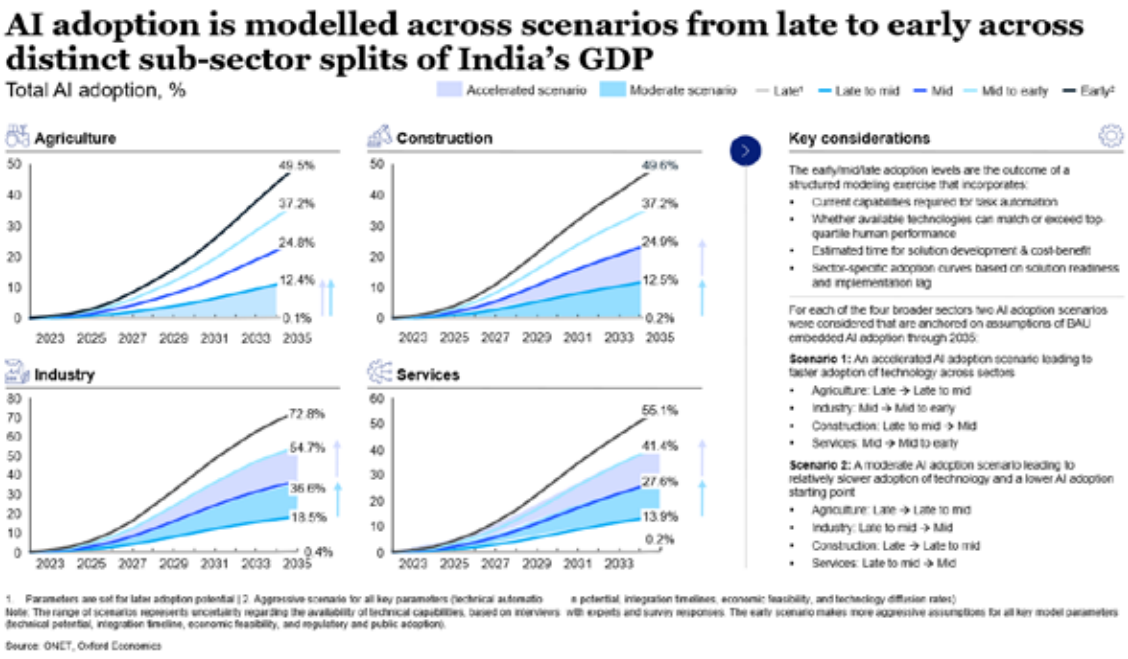
- **Baseline employment and GDP data:** Used 2022 as the baseline year for both employment and real GDP, sourced from IHS. Calculated productivity as GDP per worker to set the reference point for future projections
- **AI adoption rates for 2035:** Estimated sector-level AI adoption rates using McKinsey Global Institute's (MGI) model, covering about 850 occupations and 2,100 activities with sectoral nuances. Applied these AI adoption rates to baseline employment to determine workforce segments likely to be automated
- **Growth rates across different scenarios:** Augmented workforce calculated by redeploying the automated workforce at current productivity levels. New GDP projected by applying 2022 productivity to the augmented workforce. This yielded GDP CAGR over 2022–2035, forming the basis of Lever 1 sectoral projections
- **Relevant scenarios chosen (illustrated below in Exhibit 3):** For each sector, AI adoption across early, mid, and late horizons, under two cases were modeled- AI adoption scenarios across late, mid and early for each sector. Acceleration is assumed at two levels, leading to two scenarios: the accelerated AI adoption scenario assumes faster tech adoption with sectors shifting to earlier phases by 2035, while the moderate scenario assumes slower adoption and later starting points
- **GDP 2024 and business-as-usual CAGR 2024-2035:** Estimated sector-wise data from the IHS database, extrapolated to align with government projections for a total of $3.6T with sectoral nuances
- **Final incremental AI productivity impact value:** Derived using an additional productivity boost to the expected business-as-usual CAGR and then applying it to the GDP 2024 numbers to receive GDP with AI adoption

Assumptions

Below are the key assumptions that have been considered in the model (Exhibit 3):

- The model evaluates current capabilities required to automate tasks in each sector based on their complexity and AI readiness
- Technologies are assessed on whether they can match or exceed the performance of top-quartile human workers for specific tasks
- Adoption considers the estimated time to build viable AI solutions and whether they are economically justified from a cost-benefit perspective
- The degree of AI adoption in a sector is closely linked to its occupational structure (i.e., task types and automatable roles)
- Displaced workforce due to AI is assumed to be redeployed within the same sector, maintaining existing sectoral labor productivity levels
- While India has historically seen slow AI adoption, sector-specific improvements in digital infrastructure and technology maturity can enable faster adoption going forward
- Adoption trajectories differ by sector based on readiness of solutions, implementation lag, and cost-benefit feasibility
- Productivity gains are expected to be redeployed at similar levels or with a reduction of up to 20%

Exhibit 3

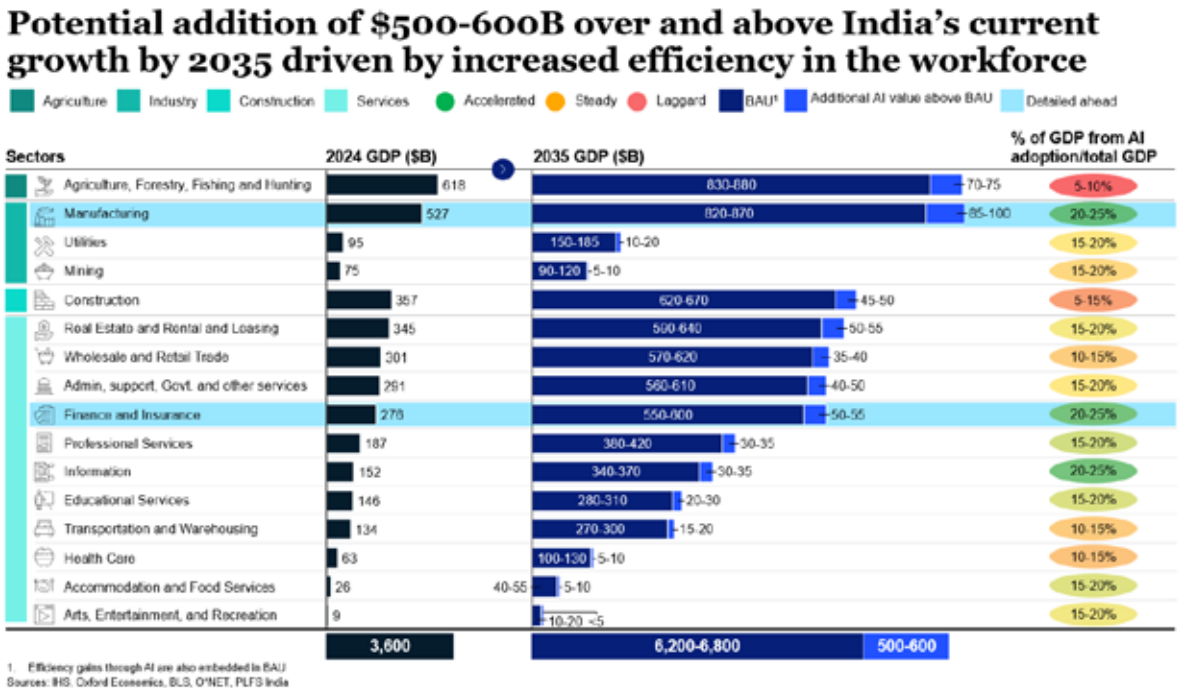


Results

The results indicate that accelerated adoption of AI across industries can contribute $500B-$600B over and above India's current GDP growth by 2035, driven by increased productivity and efficiency in the workforce (Exhibit 4). The analysis shows that financial

services and manufacturing can be most impacted and might have up to 20-25% of their sectoral GDP attributed to AI by 2035. Both sectors are detailed in the sections ahead.

Exhibit 4



Banking

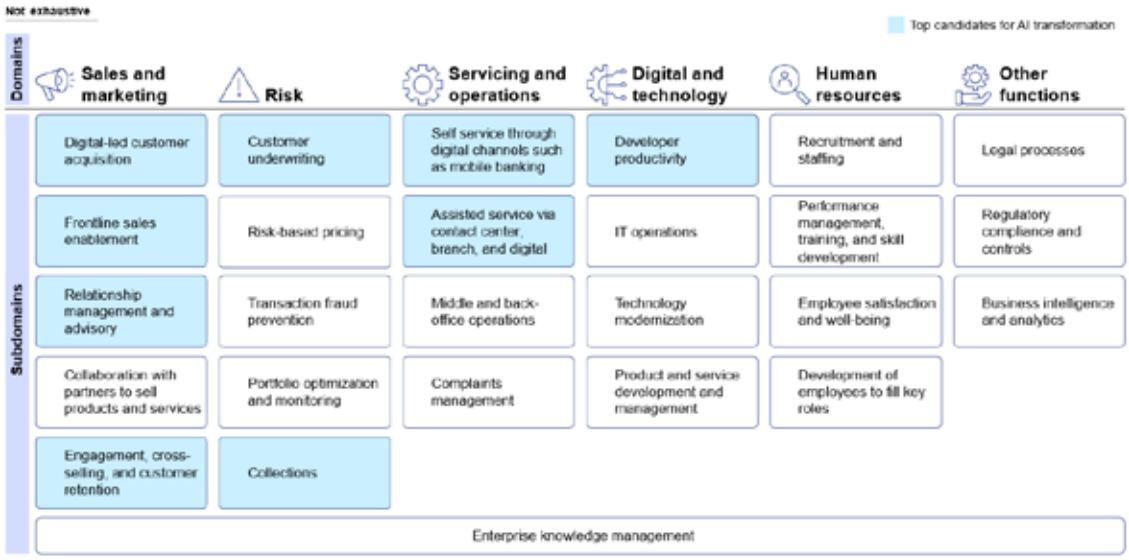
AI-led productivity and efficiency improvement could unlock $50B-$55B in financial services, over and above the current estimated growth for the sector by 2035 (Exhibit 4). This opportunity will likely be realized as AI-mature Indian banks evolve into "bionic" organizations, combining machines' intelligence with humans' judgment. AI accelerates business and functional transformation across the banking value-chain, embedding intelligence into every product, process and customer interaction. Reducing costs can also enhance financial inclusion.

Financial services companies' front, middle and back offices are expected to be transformed by machine learning and agentic AI. While the map represents important opportunities across domains, areas with potentially the highest ROI have been highlighted (Exhibit 5):

- **In the back office**, AI could power automated compliance, fraud detection, and risk management through advanced anomaly detection techniques and privacy-preserving analytics such as secure multi-party computation and federated learning
- **In the middle office,** AI-enabled systems can reshape credit decisioning, collections, and portfolio management. By leveraging alternative data sources, banks can make more accurate, dynamic, and inclusive lending decisions
- **In the front office,** virtual relationship managers can deliver hyper-personalized customer experiences. Using real-time behavioral predictions, these AI agents can offer tailored financial advice, timely product recommendations, and proactive outreach, helping deepen customer engagement and improve satisfaction across segments

Exhibit 5

To boost E2E value, banks can reimagine select business areas to undergo an AI transformation...



...and a combination of AI & machine learning can transform financial services across the front, middle, and back office

●Front office ●Middle office ●Backoffice

- **Digital-led customer acquisition**

  Adaptive look-alike models scan daily click-stream, score prospects, and auto-shift ad budgets toward the highest-conversion channels, boosting CAC efficiency.

- **Relationship management and advisory**

  Generative assistant assembles concise portfolio snapshots, flags risk or life-event triggers, and drafts personalized action plans for the relationship manager (RM) to approve and send

- **Customer underwriting**

  Explainable ML combines bureau, cash-flow, utility, and GST feeds to deliver real-time affordability scores with clear reason codes for the credit officer and the regulator.

- **Self-service through digital channels**

  Multilingual chatbot authenticates with biometrics, handles KYC updates, disputes, and card blocks end-to-end, and escalates only edge cases to a human agent.

- **Developer productivity**

  AI pair-programmer auto-writes routine code, adds unit tests, tunes SQL queries, checks for security issues, and flags build problems before the code is merged.

- **Frontline sales enablement**

  Real-time call co-pilot transcribes the conversation, matches needs to product bundles, inserts mandatory compliance language, and logs next steps straight into the CRM.

- **Engagement, cross-selling, and customer retention**

  Life-stage engine analyses transaction patterns and sentiment to predict churn or upsell windows, then launches hyper-targeted offers via push, email, and RM dashboard.

- **Collections**

- The early delinquency model prioritizes overdue accounts, picking the best channel, timing, and repayment offer to maximize recovery at the lowest collection cost.

- **Assisted service**

- (contact center, branch, digital)

  Voice analytics gauges sentiment and intent mid-call, suggests relevant knowledge-base snippets, while back-office bots auto-populate and route service tickets.

Potential enablers for consideration

Realizing the full potential of AI in India's banking sector will depend on a set of enablers that support innovation, adoption, and responsible scaling. These include:

Infrastructure

- Building capacity through Innovation Sandboxes to enable pilots focused on critical themes such as explainable credit models, fraud and AML graph analytics, and self-auditing regulatory technologies
- Utilizing a regulatory sandbox to test AI-related regulatory changes, e.g., video KYC for NRI.
- Harness open, standardized dashboards from pilots to track business impact, fairness outcomes, and emerging risks, enabling transparent supervision and learnings across the ecosystem
- RBI has already announced the establishment of a public cloud infrastructure for the financial sector[14]. Such efforts can be accelerated:
  - → An empaneled set of vendors offering high-performance compute (e.g., GPUs), privacy-preserving tools, and LLM-based APIs
  - → Strong data protection frameworks, including data replication, disaster recovery, and compliance checks
  - → Pre-approved toolsets for common banking use cases, made easily accessible through a curated marketplace
- Define standards for and enable access to utility agents, trained on regulatory-grade datasets and made available to banks and other financial institutions. RBI can define standards to ensure these agents are explainable, compliant, and regularly updated to reflect regulatory changes and market evolution
- Harness a cross-regulatory AI Innovation Sandbox to enable financial institutions to test models in a secure environment alongside the regulatory sandbox.
- A shared "landing zone" for GPUs and computing resources on a pay-per-use basis for smaller regulated entities, delivered via RBI or sector infrastructure providers.
- A dedicated funding corpus could support shared data and compute as public goods, including grants for fintech accelerators and research labs.
- A sector-specific AI model for finance and make them available for safe adoption across the sector.

14 Reserve Bank of India. Monetary Policy Statement. December 8, 2023.

Data

- A central regulatory body for data governance in the financial sector. It could include, but not be limited to, defining standards for classification of data, sharing across entities, responsible use, security, and monetization.
- Defining frameworks (either enhancing existing or developing new ones) to include alternative (especially unstructured) data sources, under a unified consent and governance structure. An adequately authorized entity, such as the India Data Management Office (IDMO), can standardize look at access issue to ensure borrower opt-outs, and enable explainable scoring aligned with regulatory norms
- Harness existing data architecture frameworks to facilitate secure, anonymized data exchanges between banks and other financial institutions for the purpose of model training, ensuring privacy and transparency
- Broader adoption of alternative data by banks through enabling policies and common infrastructure. An adequately authorized entity, such as the RBI, could:
  - → Issue clear guidelines on the use of such data for credit and other financial decisions
  - → Establish a shared, consent-driven data repository, accessible to regulated entities
  - → Promote standardization and interoperability for secure data access and validation
- Consider whether a financial institution could maintain a regular inventory of its AI systems, with anonymized metadata fed into a sector-wide repository for supervisory visibility.
- AI can be more deeply integrated with existing digital public infrastructures (e.g., UPI, AA, OCEN) to support enhanced public services such as multilingual access and fraud detection.

Talent

- Training programs focused on the needs for the financial sector. As an example, a national certification program in AI for Credit, Risk and Fraud could be considered by the government, industry organizations, and universities. This would build trusted and domain-aligned talent with expertise in responsible AI, explainability, and financial regulation
- Consider whether tax incentives on course fees for financial institutions could increase investment in skilling employees in AI, analytics, and cybersecurity. This would reduce the post-tax cost for employers and spur large-scale adoption of upskilling programs
- A scalable and flexible talent pool through a national AI fellowship or exchange platform:
  - → Maintain a vetted database of certified AI professionals available for temporary deployments across banks, and other financial institutions, including regulators
  - → Allow small and mid-sized institutions to access top talent on-demand without full-time hiring overheads

→ Facilitate secondments or rotational programs across banks, RBI innovation arms, and academia to deepen cross-sectoral expertise and rapid capacity building

Protection, Assurance and Governance

- **Consumer protection and transparency** by mandating fairness in AI outcomes, clear disclosures on AI use, and accessible grievance redressal mechanisms, supported by public reporting and toolkits that help smaller firms meet compliance.
- **Resilience and security** through continuous cybersecurity monitoring, dynamic threat response, regular red-teaming of AI systems, and business continuity plans with fallback mechanisms and drills.
- **Governance and oversight** by requiring AI-specific risk checks in product approval processes, continuous monitoring of deployed models, institution-level AI inventories feeding into a sector-wide repository, and risk-based audits (with independent third-party audits for high-risk systems).
- **Accountability through incident reporting and risk intelligence** by establishing tolerant, good-faith reporting mechanisms and aggregating disclosures to generate sector-level insights on emerging risks.

Key risks

While AI in banking offers significant promise, India must also navigate a set of risks that could impede adoption.

●Data ●Infrastructure ●Talent ●Regulatory and IT Policy

●● **Legacy IT core infrastructure**

Most banks still operate on bulky legacy core platforms. Integrating AI tools often requires extensive rework or replacement, adding cost and multi-year delays to realize productivity benefits. These delays will persist without sovereign AI/cloud infra and curated toolsets.

●● **Sandbox throughput constraints**

Unlock the Innovation Sandbox's capacity to evaluate important interventions along the financial services value chain. Without open dashboards and dissemination of learnings, systemic benefits will remain limited.

●● **Lack of scalable AI utility infrastructure**

Absence of centralized AI tools, agents, and vetted vendors for common banking use cases forces every bank to reinvent the wheel. This fragmentation hinders innovation velocity and increases cost.

●● **Upskilling & change management**

Without clear roles, staff training, and guardrails, using AI agents can lead to errors, compliance issues, and serious risks to customer trust and system stability.

● **Data coverage and quality gap**

Despite the push for Account Aggregator (AA) and DEPA frameworks, many individuals remain outside the digital data net, especially in low-digitization areas. A lack of standardized and consent-driven repositories further limits the availability and reliability of alternative data for AI models.

●● **Privacy and consent fatigue**

Consumer privacy concerns around alternative data are intensifying. Without robust data protection, explainability, and opt-out frameworks, public trust may erode, constraining data access.

●● **Unequal access to AI talent and tools**

Smaller banks and fintechs may lack the resources to tap into centralized utility agents, high performance compute environments or rotational AI pools, reinforcing a digital divide within the financial sector.

Manufacturing

In manufacturing, $85–100B could be driven by AI-led productivity and efficiency improvement over and above India's current growth by 2035. The National Manufacturing Mission outlines five key pillars[15]: Ease of Doing Business, Future-ready Workforce, Vibrant MSME Sector, Availability of Technology, and Quality Products, of which AI will have a high impact on three: Availability of Technology, Future-ready Workforce, and Vibrant MSME Sector.

AI can unlock productivity and efficiency across multiple dimensions by lowering the cost of production, improving output yields through enhanced process efficiency, and increasing throughput via predictive maintenance on the shop floor. It can also enable the production of higher-quality goods at similar prices by powering intelligent product design, real-time quality control, and mass customization. To fully realize these benefits and build a future-ready, competitive industrial base, upskilling India's manufacturing workforce in AI tools will be essential (Exhibit 6).

For India to fully capture the gains from AI-native manufacturing, it is important to strengthen both forward and backward linkages. On the backward side, this means building resilient supply chains, integrating AI-ready MSMEs, and ensuring reliable access to inputs. On the forward side, India can actively expand domestic markets and position itself in global value chains through coordinated industrial and trade policies. Productivity gains alone will not deliver impact unless industrial policy, trade strategy, and demand generation evolve together to convert efficiency into competitiveness and growth.

Exhibit 6

15 Press Information Bureau, Government of India. "'National Manufacturing Mission' to cover small, medium and large industries for furthering 'Make in India' announced in Union Budget 2025-26." February 1, 2025

Potential enablers for consideration

Realizing AI's full potential in India's manufacturing sector will depend on enablers that enhance productivity and foster innovation-driven growth at scale.

Infrastructure

- "AI-Ready Industrial Parks" that place clean-energy factories next to high-performance computing (HPC) labs and skills centers, similar to the technology-and-fabrication clusters promoted under the United States CHIPS and Science Act
- Government decision makers to look at -funding shared facilities for 3-D printing, advanced materials testing and precision metrology can give MSMEs affordable access to expensive equipment
- Robotics and humanoid test zones with safety rules that allow rapid prototyping, already being done in several Chinese electric-vehicle (EV) hubs, could speed up local innovation in collaborative robots and vision-guided welding stations
- A national BharatNet fibre backbone with Time Sensitive Networking (TSN) - capable switches will let control signals travel reliably between separate buildings or even distant factories that share the same production line
- An online SaaS marketplace where Indian and global developers can publish plug-and-play AI tools, for example, for anomaly detection or energy optimization, which will let factories subscribe to the exact algorithms they need instead of investing heavy capital upfront

Data

- An open "Manufacturing Data Grid," a shared platform where OEMs, suppliers, other stakeholders, and startups can trade production and supply-chain data through standard APIs, taking inspiration from Germany's Manufacturing-X data-space model
- Industrial parks to house both cloud servers and edge computers equipped with GPUs so that high-speed quality checks, digital twins and predictive-maintenance systems can run close to the machines that generate the data
- Industrial clusters with 5G and 6G mobile networks combined with Time-Sensitive Networking (TSN) switches so robots and Automated Guided Vehicles (AGVs) can send and receive data without delay
- Data sharing framework for manufacturing so that companies can share sensitive design drawings or process settings only with trusted partners and always with clear, revokable permissions
- National libraries (or marketplaces) of reusable digital-twin models, for example, for semiconductor fabrication plants, battery-cell lines, precision auto-parts machining and aerospace composites to shorten design cycles without starting every simulation from scratch

Talent

- The Ministry of Skill Development, the All-India Council for Technical Education (AICTE) and leading manufacturers could explore how to launch a tiered "AI for Advanced Manufacturing" program that starts with micro-badges and scales up to full

postgraduate programs, following Japan's Ministry of Economy, Trade and Industry (METI) model for rapid AI upskilling[16]

- Industry-academia research chairs in specific domains, e.g., chip design, power electronics, robotics and battery chemistry to allow professors and graduate students to work on real-world factory challenges while keeping intellectual property inside India
- Government decision makers could assess the benefits of a targeted reverse-diaspora program that offers fast-track visas, research grants and senior leadership roles to encourage experienced semiconductor, battery and automation experts living abroad to return and teach or build in India
- A national registry of certified freelance AI-maintenance engineers, digital-twin modelers and automation troubleshooters that will help factories scale their specialist workforce up or down

Key risks

Risks that could hinder India's push toward AI-native manufacturing include

●Data ●Infrastructure ●Talent ●Regulatory and IT Policy

- ● **Fragmented data ecosystem**

  Without a standardized Manufacturing Data Grid and common APIs, production and supply-chain data will remain siloed across OEMs, MSMEs, and startups. This limits AI's ability to deliver end-to-end visibility and optimization.

- ● **Inadequate edge + network infrastructure**

  AI use cases like digital twins or predictive maintenance need low-latency computing close to machines. Many parks lack edge GPUs, 5G/6G, or TSN-capable networks slowing adoption.

- ● **Shortage of cross-skilled talent**

  India's AI workforce has room to deepen expertise in manufacturing (e.g., robotics, chip design, battery tech). Upskilling via tiered credentials and reverse diaspora programs is critical but currently limited in scale and alignment with real factory needs.

- ● **Low awareness and access to shared AI infrastructure**

  MSMEs often can't access HPC labs, 3D printing centers, or plug-and-play SaaS AI tools due to cost, geography, or lack of knowledge, widening the gap between large OEMs and small suppliers.

- ● **Slow adoption of DEPA-like consent protocols**

  Sharing sensitive factory data (e.g., designs, process settings) is essential for collaborative AI. Without robust consent-based, revokable frameworks, companies may avoid data sharing due to IP fears.

- ● **Slow industry readiness tracking**

  Without government support and structured assessments like SIRI, many MSMEs and smaller organizations may struggle to identify critical skill or technology gaps—slowing their ability to scale and transition toward Industry 5.0.

AI adoption across industries represents a critical lever for India to enhance productivity and competitiveness, with banking and manufacturing standing out as early opportunities. Building on these foundations, the next chapter explores Lever 2: Unlocking leapfrog innovation by transforming R&D with AI—a pathway for India to accelerate discovery, shorten innovation cycles, and establish a stronger foothold in global, innovation-driven industries.

16 Ministry of Economy, Trade and Industry (METI), Approaches to human resources and skills required for DX promotion in the age of generative AI, August 7, 2023.

CHAPTER 4 – LEVER 2: UNLOCK LEAPFROG INNOVATION BY TRANSFORMING R&D WITH AI

Transforming R&D, especially using generative AI, can enable India to leapfrog into innovation-based opportunities on a global scale by transcending traditional growth pathways and creating new products, services, and business models. Historically, such innovation paths have been challenging for India due to the heavy capital required for conventional R&D, e.g., $1–2B[17] for novel drug development and $1–1.5B to engineer an all-new electric vehicle platform. AI lowers these entry barriers. It can accelerate commercialization, disrupt legacy value chains, and create a lasting competitive edge. Analysis suggests that such breakthrough innovations could potentially contribute at least an incremental $280-475B to India's GDP by 2035.

Approach

11 sectors have been selected from McKinsey's 18 global arenas[18] of growth and 7 additional India-specific arenas based on their local relevance and transformative potential.

- Baseline (2023) revenues across all 18 arenas were sourced from current industry reports and total $640–750B[19]. Projections for 2030 were developed using a combination of industry estimates and expert consultations (e.g., ONDC for next-gen e-commerce), reaching $1.7–2.0T
- The 2035 revenue projections were developed using 2023–2030 growth trends, resulting in an estimated $3.6–4.5T range. To assess the incremental GDP contribution, the revenue delta from 2023 to 2035 was calculated and sector-specific revenue-to-GDP conversion factors were applied, resulting in a projected GDP impact of $1.4–1.9T across all 18 arenas by 2035
- Out of 18 arenas, 10 were identified where AI is the primary value driver for leapfrog growth. These 10 arenas are expected to contribute $380–660B in incremental GDP impact by 2035
- This yields an estimated $280-475B in incremental GDP attributable specifically to AI-led leapfrog growth across the 10 arenas by 2035

The exhibit below shows the identified 18 arenas of growth that could serve as key drivers of India's growth over the next decade, with a projected GDP impact of $1.4–1.9T by 2035.

17 World Economic Forum article titled "How blockchain can cut the cost of new medicine". December 2018.

18 McKinsey Global Institute report titled "The Next Big Arenas of Competition". October 23 2024 – 18 global arenas of which 11 are directly relevant for India and 7 additional were added

19 McKinsey article titled "India's Future Arenas: Engines of Growth and Dynamism". June 19 2025.

Exhibit 7

India's 18 areas of growth contribute to $1.4T - $1.9T in incremental GDP by 2035

Global 18 arenas report

(A) Opportunity area	Revenue ($B) 2023	2030	2035	Incremental GDP[1] (E) ($B) 2035
Next-gen e-commerce	60-70	240-300	700-800	450-500
Tourism and travel	160-170	360-420	680-750	370-420
Urban construction	170-190	400-490	800-900	200-250
AI software and services	5-10	40-50	150-200	100-150
Cloud services	15-20	70-80	200-250	100-150
Global hub for Auto Components	70-75	160-190	300-350	50-100
Cybersecurity	30-35	65-80	100-150	50-100
Software assisted vehicles[2]	5-10	40-60	180-230	30-50
Semiconductors and PCBs	40-45	100-120	200-250	30-50
Renewables with storage system	20-25	50-70	100-150	20-40
Medical devices	10-15	25-35	50-100	10-20
Bio-based energy and materials	10-15	30-40	50-100	10-20
Space Tech	5-10	20-30	40-80	5-15
Aerospace and defence	20-25	40-50	50-100	5-15
Nuclear power	2-4	10-15	20-40	5-15
Biopharma	5-10	20-25	40-60	5-15
Industrial electronics	10-15	20-25	20-40	2-8
Industry 4.0	1-2	2-3	5-10	1-2
Total	(B) 640-750	(C) 1,700-2,000	(D) 3,600-4,500	1,400-1,900

Key considerations

(A) India's 18 arenas team selected **11 areas from Global 18 arenas work** and identified **7 additional India-specific arenas**

(B) **Baseline revenues** for all 18 arenas **sourced from current industry reports**

(C) **2030 revenue projections** were derived **using industry reports and expert consultations** (e.g., ONDC for next-gen e-commerce)

(D) 2035 revenues are **extrapolated using the 2023–30 growth** factor

(E) **Incremental GDP estimated** by calculating **revenue delta between 2023 and 2035**, then **applying sector-specific revenue-to-GDP conversion factors** (ranging from 22% to 71%)[1]

1. Calculating using sectoral revenue to GDP factor. Source: HIS sector wise data for value added output and gross output | 2. Largely driven by electric vehicles

Of the 18 arenas of growth, ten are primarily driven by AI-led innovations such as AI software and services, a global hub for auto-components, cloud services, software-assisted vehicles, semiconductors and PCBs, medical devices, SpaceTech, aerospace and defense, cybersecurity, and biopharma (see exhibit below).

Exhibit 8

$280B-$475B incremental GDP opportunity via 10 arenas of growth, primarily driven by AI-based leapfrog growth

10 opportunity industries primarily driven by AI based leapfrog growth

xx High AI impact (80%) xx Medium AI impact (50%) xx Low AI impact (40%)

(A) Opportunity area	Revenue ($B) 2023	2030	2035	Incremental GDP[1] ($B) 2035	
AI software and services	5-10	40-50	150-200	100-150	80-120
Cloud services	15-20	70-80	200-250	100-150	80-120
(C) Global hub for Auto Components	70-75	160-190	300-350	50-100	30-60
Cybersecurity	30-35	65-80	100-150	50-100	40-80
Software assisted vehicles[2]	5-10	40-60	180-230	30-50	20-30
Semiconductors and PCBs	40-45	100-120	200-250	30-50	20-30
Medical devices	10-15	25-35	50-100	10-20	5-10
Space Tech	5-10	20-30	40-80	5-15	2-8
Aerospace and defence	20-25	40-50	50-100	5-15	2-8
(C) Biopharma	5-10	20-25	40-60	5-15	2-8
Total	200-250	580-720	1,300-1,800	(B) 380-660	(D) 280-475

Key considerations

(A) **10 areas identified** where **AI-driven leapfrog growth is the primary value driver**

(B) Estimated **$380-660B in incremental GDP impact from these ten arenas** by 2035

(C) To account for overlaps across categories, a **40-80% attribution factor was applied to estimate AI-based leapfrog value capture** basis level of AI impact

(D) This yields an estimated **$280-475B in incremental GDP impact of AI-based leapfrog growth from these 10 arenas** by 2035

1. Calculating using sectoral revenue to GDP factor. Source: HIS sector wise data for value added output and gross output | 2. Largely driven by electric vehicles

It is important to recognize that AI-led growth will be shaped by unexpected breakthroughs that remain beyond our foresight today. AI is advancing at an extraordinary pace with

AI supercomputing capacity doubles every 8–10 months.[20], and AI algorithmic efficiency doubles every 15–18 months[21]. Given this velocity, it is difficult to anticipate the full spectrum of innovations that may arise. While 18 opportunity industries for India have been identified, the rapid evolution of AI could well unveil a 19th or 20th frontier that will likely emerge over time.

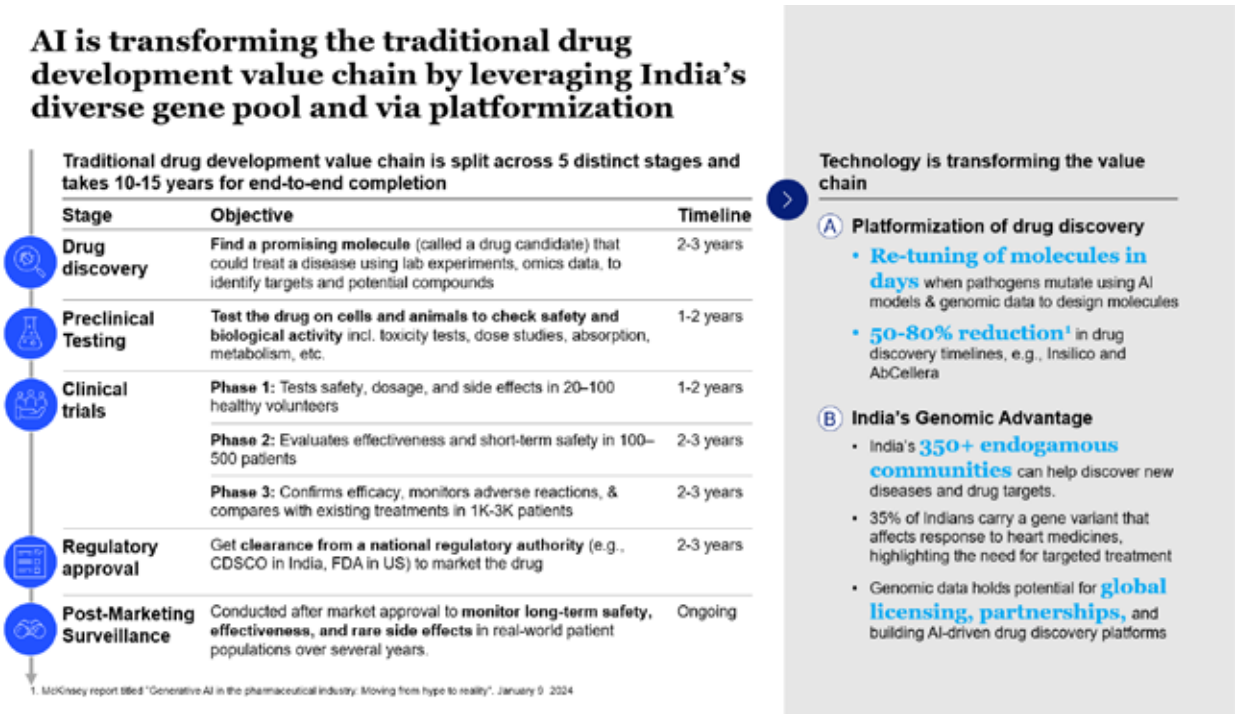
The next section illustrates the AI-led opportunity in the pharmaceuticals and automotive sectors, which are aligned with India's factor endowments.

Pharmaceuticals

Currently, 80% of the Indian pharmaceutical market is driven by generics[22]. This is because the high costs of developing a novel drug (up to $1–2B per molecule)[23], long timelines (over 10 years)[24], and significant financial risks have historically limited investment in innovative R&D capabilities. Emerging technologies such as AI can help lower development costs and timelines across the drug discovery and development value chain, enabling India to transition from generics to the innovator space over the next decade. India's expertise in generics, domain talent (e.g., pharmacology) and its endowment in the form of a rich genetic pool can position it well to capture this opportunity.

Traditional drug development is divided into five distinct stages and typically takes >10 years to complete end-to-end, with a potential capital spend of $1–2 billion (Exhibit 9).

Exhibit 9



20 arXiv preprint titled "Trends in AI Supercomputers". April 22 2025

21 Forethought Research article titled "Will AI R&D Automation Cause a Software Intelligence Explosion?" March 25 2025

22 IQVIA market data

23 World Economic Forum article titled "How blockchain can cut the cost of new medicine". December 2018

24 N-SIDE blog post titled "What's the average time to bring a drug to market in 2022?". November 5 2022

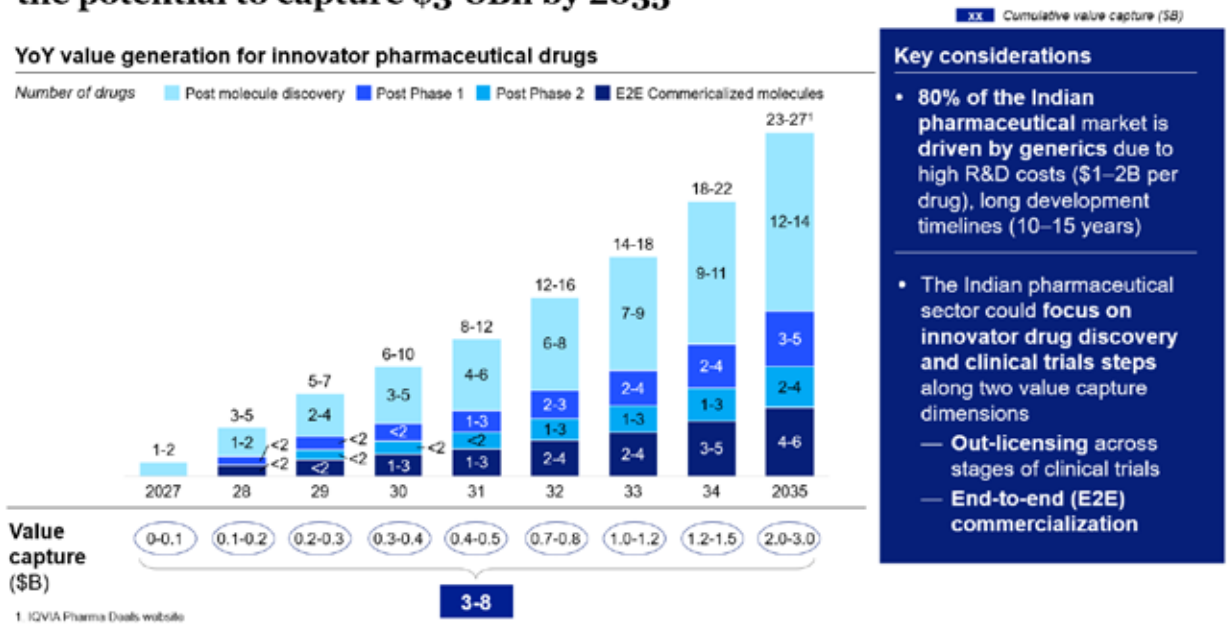
AI is re-shaping the traditional drug discovery value chain. It could reduce R&D costs by 20–30%[25] through drug repurposing, AI-driven research and documentation, and replacing traditional placebo groups in clinical trials with AI-generated virtual placebos. This can simulate control groups without needing real participants; shorten drug discovery timelines by 60–80%[26] via AI-powered molecule design and Insilico modelling to speed up lead identification by four times; improve clinical trial success rates by 5–15% by leveraging India's diverse gene pool to identify optimal patient subgroups.

Additionally, frontier technologies are creating new pathways for drug development. Platform-based approach is enabling the creation of reusable, end-to-end technology engines that can discover, design, and optimize multiple drugs across therapeutic areas by integrating AI models, large-scale genomic data, and automated lab systems. One key advantage of this approach is the ability to repair or retune existing molecules in days or weeks when a pathogen or tumor mutates, avoiding the need to restart the discovery process from scratch For example, a Boston based startup advanced a novel lung fibrosis drug from concept to Phase 1 trials in under 30 months, while another Canada-based startup developed a COVID-19 antibody in just 90 days using its AI-driven antibody discovery platform.

India could consider licensing and launching 90–110 innovative drugs by 2034 across four phases: post-molecule discovery, post-phase 1, post-phase 2, and E2E commercialization. This would culminate in a value capture of $5–8B and establish India as an innovation-led hub (Exhibit 10).

Exhibit 10

The Indian pharmaceutical sector could focus on innovator drugs with the potential to capture $3-8Bn by 2035



25 McKinsey report titled "Generative AI in the pharmaceutical industry: Moving from hype to reality". January 9 2024

26 McKinsey report titled "Generative AI in the pharmaceutical industry: Moving from hype to reality". January 9 2024

Potential enablers for consideration

Realizing value in pharmaceuticals could depend on enablers to improve clinical research, optimize manufacturing and ensure regulatory readiness.

Infrastructure

- Expanded the number of biotech parks by 10x to support the predicted expansion in research and development led by the growth of startups
- High-performance computing infrastructure in line with EU and China to meet the intensive computational needs of AI-driven drug discovery

Data

- Diverse genomic and clinical datasets to build a unified, high-quality national omics dataset, led by institutions such as the Indian Biological Data Centre (IBDC) and Biotechnology Industry Research Assistance Council (BIRAC)
- A tiered data access model like the U.S. National Institutes of Health's "All of Us" program, providing public, registered, and controlled access levels to researchers[27]

Talent

- Train and retain biopharma R&D scientists by 2035 to support the annual development of 20–25 new drugs (Exhibit 10)
- Undergraduate and postgraduate programs in computational biology and bioinformatics in collaboration with premier technical institutes
- Expanded central research grant pools to have a dedicated track for AI in drug discovery that focuses on attracting global talent
- Enhanced re-entry fellowships with increased stipends and research grants to match global talent programs

Policy and Regulations

- Government decision makers could review India's pharmaceutical regulations to ensure they align with global standards to facilitate faster clinical trials and international recognition
- Government decision makers could explore the potential benefits of a data exclusivity law that could protect clinical trial data while incentivizing innovation
- Government decision makers could explore whether there is scope to streamline the clinical trial approval process, a potential 30-day approval route for institution-initiated trials would match global best-in-class timeframes
- Government decision makers could look at how to implement global best practices for vaccine approvals, such as rolling data reviews and digital submissions that aim to shorten overall timelines for time to market

27 All of Us Research Hub article titled "Data Access Tiers"

Market Access

- A drug-access acceleration fund through BIRAC to co-invest in the commercialization of Indian therapies
- A "Made-in-India Innovation Track for Pharma" to mandate the listing of breakthrough drugs within 180 days of approval
- Empower pre-revenue biotech firms to go public by mirroring NASDAQ's non-revenue-based listing parameters
- Consider the potential benefits of offering capital incentives, such as capital grants for AI-R&D centers and reduced tax rates on profits from India-patented drugs
- Global pharmaceutical firms with priority access to national high-performance computing infrastructure and a 180-day fast-track approval path for AI-designed drugs

Key risks

India's goal of AI-based drug development faces potential risks

●Data ●Infrastructure ●Talent ●Regulatory and IT Policy ●Market access

- **Value erosion**

  U.S. market reforms could cut global drug out-licensing value[28], sharply curbing the earnings potential of Indian-origin therapies.

- **Slow and uncertain domestic market**

  Unless the pharma regulatory body shortens drug-approval timelines from 20–25 months to 15 months, matching global benchmarks, each year of delay can erode 10-15% of an asset value.[29].

- **Unclear guidelines on AI-discovered drugs**

  Global patent norms requiring "significant human contribution" may limit protection for AI-generated molecules, risking rejection and long-term barriers to global commercialization in key markets.

- **Genomic data gap**

  Reaching the omics dataset target by 2035 faces major risks, high capex, potential legal backlash over consent, and low participation due to rising privacy concerns.

- **High-performance compute bottleneck.**

  AI in drug discovery requires dedicated HPC capacity, but risks like lack of funding, global GPU shortages, 70+ week lead times[30], and export controls could delay deployment by 18–24 months.

- **R&D talent gap**

  India's low researcher density and uncompetitive stipends may hinder progress toward the 2035 target of 1.5k researchers per million, unless talent training and retention improve.

Automotive

AI can emerge as a game changer for the automotive sector in India, enabling it to cut costs, improve safety and accelerate innovation. In the following sections, the report explores two pathways for automotive: Software-Assisted Vehicles (SAVs) and AI-enabled component design. Harnessing frontier technologies, including RFID-based smart corridors, 5G-connected routes, and AI-driven design and validation, could put 18-20M software-ready vehicles on Indian roads by 2035 and unlock $20-25B in export gains and import substitution. (Exhibit 12 and Exhibit 14)

28 OHE bulletin titled "US drug pricing policies will have global impacts on innovation and access". June 30 2025
29 McKinsey article titled "The road to positive R&D returns"
30 Industry Technology Report titled "Prepare for the Coming AI Chip Shortage". September 25, 2024

Software-assisted vehicles (SAVs)

Software-Assisted Vehicles (SAVs) represent the next generation of automobiles, where core functionalities are increasingly driven by software rather than hardware-intensive systems. SAVs operate across five defined levels of autonomy, as per the Society of Automotive Engineers (SAE) International (Exhibit 11). The automotive industry in India is presently concentrating its efforts on progressing from Level 2, which features partial vehicle autonomy, towards achieving Level 4, characterized by highly autonomous driving capabilities. These vehicles rely on flexible electronic architectures, connected systems, and over-the-air (OTA) updates to minimize human intervention.

India is expected to reach Level 3 by 2035, with its AI-led automotive inflection point between Levels 3 and 4. As India emerges as a major SAV consumer market and global production hub, this shift offers a key opportunity for domestic value creation and global competitiveness.

Exhibit 11

India's leapfrog to intelligent mobility begins with level 2 autonomy with an estimate to reach level 4 autonomy by 2035

Focus area

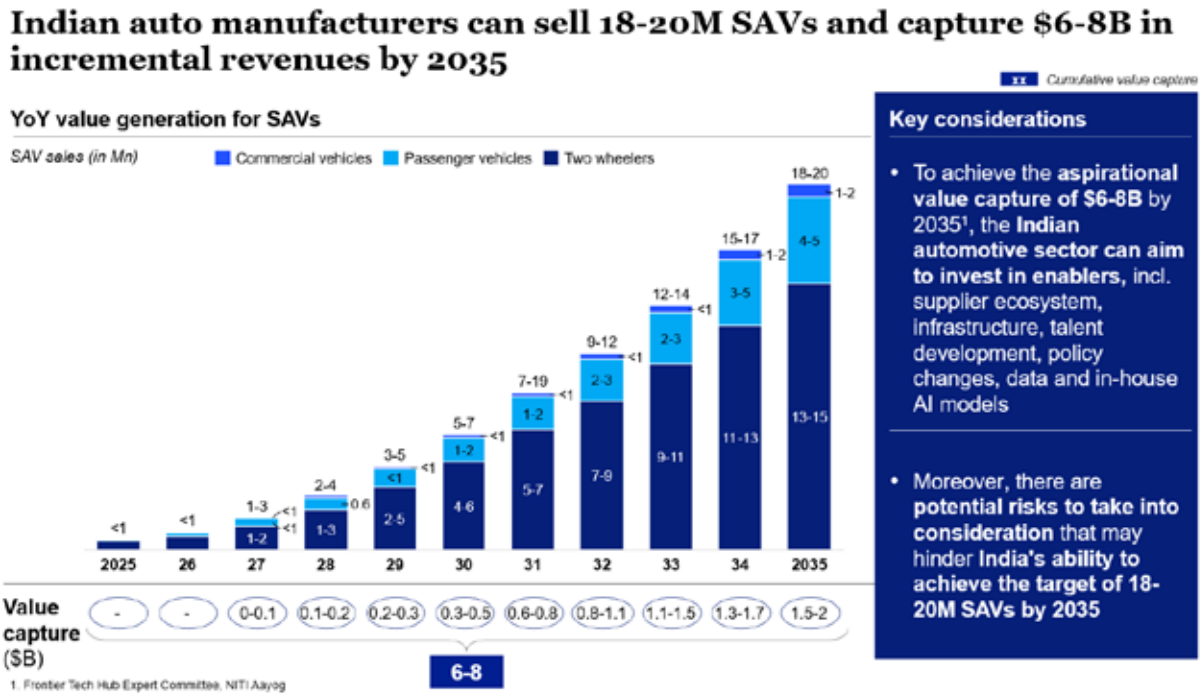
	Level 1: Driver assistance[1]	Level 2: (A) Partial autonomy	Level 3: (B) Conditional autonomy	Level 4: High (C) driving autonomy	Level 5: (D) Full autonomy	Key considerations
Description	Vehicle **assists with either steering or speed**; driver continually manages other tasks and monitors surrounding environment	Vehicle **simultaneously controls steering and speed**, driver must supervise roadway and intervene when needed	**System monitors driving environment**, performing all tasks; driver resumes control promptly when the system requests	Automated **system drives entirely within geofenced conditions**; no human needed, vehicle executes safe fallback	**Vehicle performs every driving function** anywhere, any weather; humans ride solely as passengers without backup role	(A) India's vehicles are currently at level 2 autonomy (B) India is projected to be at level 3 autonomy by 2035 in current scenario (C) U.S. vehicles today are at level 4 autonomy (D) Chinese vehicles today are at level 5 autonomy, i.e., surpassed U.S. (E) Between L3/L4 will India see the AI led innovation growth by 2035
Features	• Adaptive Cruise Control • Lane-Keeping Assist • Parking assist • Forward-collision/Lane-departure warnings • System disengages instantly if driver removes their hands from steering	• Lane-centering • Traffic-Jam Assist • Automatic Emergency Braking • Automatic safe stop if driver is unresponsive • Works only on mapped, well-marked roads	• System monitors roadway within ODD[1] • Automated lane changes and overtakes • Issue takeover request with warning • Hands-off control permitted on approved highways/traffic	• Full self-driving in geofenced areas • Executes a safe stop if it must leave its ODD • Steering wheel absent • Fleet monitored remotely for health	• Works in all terrain and weather conditions • No steering wheel or pedals required • Handles complex cases (uncontrolled intersections) • Automated refuel/charge • Operates without roadside or cloud dependence	

40-50% of the Indian vehicles sales across passenger, commercial and two-wheeler is expected to **be SAVs by 2035**

1. ANSI blog post titled "SAE Levels of Driving Automation", July 19 2021

By 2035, 40-50% of the total 40-45M vehicle market, i.e. 18-20M units, would be enabled via software (Exhibit 12). These will be split across passenger vehicles at 4-5M, commercial vehicles at 1-2 M and two-wheelers at 13-15M. India could unlock $6-8B cumulative domestic value through AI-enabled SAV domestic subscriptions by 2035, with an estimated $1.5-2B annual exit value that year.

Exhibit 12



A three-level autonomy-driven pathway for India's SAV evolution is considered. India's SAV evolution will move from Level 2 partial automation (driver-assisted) to Level 3 conditional automation (hands-off in specific scenarios) and Level 4 high automation (self-driving in geofenced areas).

Unlocking opportunities beyond conventional technologies

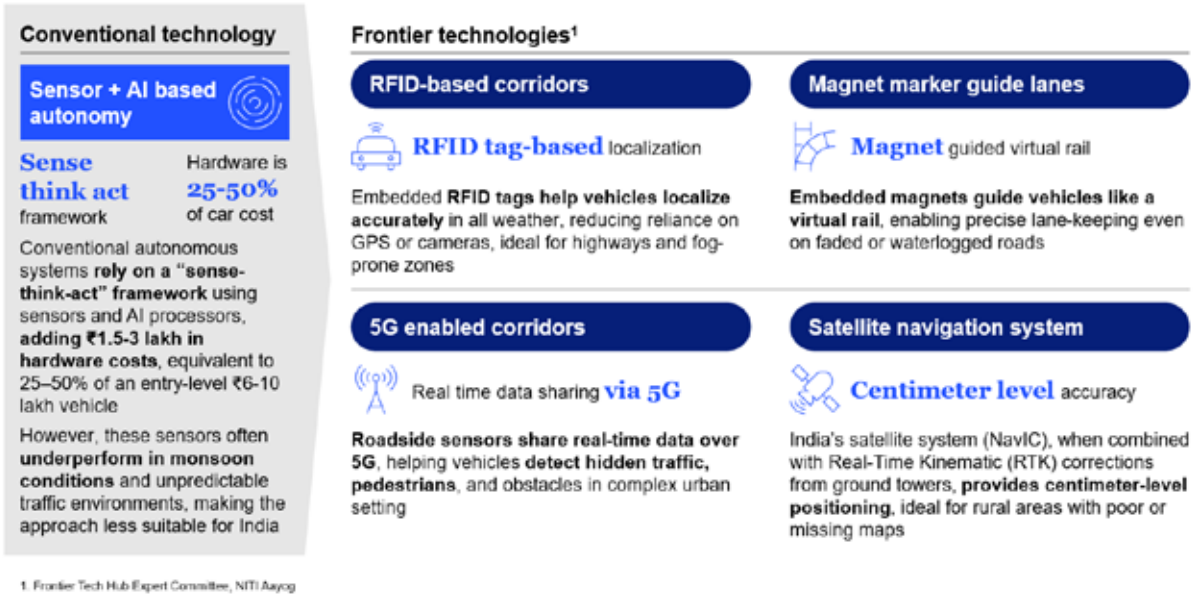
Conventional autonomous driving relies on costly on-board sensors like LiDAR, cameras, and radars combined with real-time AI processing to navigate roads without human input.

However, such systems may face challenges in India due to weather or traffic conditions and poor road markings. India can explore alternate, infrastructure-assisted approaches to enable affordable and reliable autonomy, including:

- RFID-based corridors that help vehicles localize accurately in all weather, reducing reliance on GPS or cameras
- Magnet marker guides lanes, which act like a virtual rail, enabling lane-keeping, even on waterlogged roads
- 5 G-enabled corridors that share real-time data over 5G, helping vehicles detect hidden traffic in urban settings
- Satellite navigation system in combination with real-time kinematic from ground towers provides centimeter-level accuracy ideal for remote areas (Exhibit 13).

Exhibit 13

Indian autonomous vehicles can leapfrog beyond conventional sensors + AI-based technologies to infrastructure-assisted tech



1. Frontier Tech Hub Expert Committee, NITI Aayog

To unlock $6-8B in SAV value over the next decade, AI can help accelerate engineering capability building and faster time to market for software-enabled automotive products at reduced costs. AI copilots or custom LLMs trained on AUTOSAR/ vehicle OS documents can cut learning time by 30–50%. AI-powered model-based design can reduce design cycle times by 20–30%, while AI-led bug detection and regression testing can lower validation costs by up to 40%. Additionally, AI vision and reinforcement learning can optimize component assembly and reduce Electronic Control Unit (ECU) testing costs.

Potential enablers for consideration

Realizing the full potential of shared autonomous vehicles in India will depend on enablers that build robust digital infrastructure, ensure safety and regulatory readiness.

Infrastructure

- 6–8 physical-digital testing parks[31] by 2035 to validate autonomous driving features in Indian conditions
- 10,000 km[32] of 5G/early-6G corridors with roadside units to enable real-time data exchange for software-assisted vehicles
- Designated 10-20 low-risk deployment zones by 2030 in areas such as airports and campuses for the initial commercial rollout of Level 3 and Level 4 autonomous vehicles

31 Benchmarking with testing parks in South Korea and U.S. per million cars; American Center for Mobility report titled "About the American Center for Mobility"; K-City report titled "K-City: South Korea's 5G-Connected Autonomous Vehicle Testbed"

32 Covering Golden Quadrilateral, connecting Delhi, Mumbai, Chennai, and Kolkata (~5,900 km); high-impact national corridors (~2,000 km), including Ahmedabad–Nagpur, Mumbai–Bangalore, and Delhi–Kolkata; and top 20 urban ring roads (~2,000 km)

- Three regional Zero Prototype Labs in key automotive component hubs e.g., Pune, Aurangabad that provide digital testing and simulation facilities, particularly for MSMEs and startups

Data

- Incentivized manufacturers sharing anonymized telemetry data from 20-25% of new vehicle sales annually to create a large-scale national sensor dataset. Utilize the collected data to define safety norms for semi-autonomous vehicles and identify high-risk roads for infrastructure improvements
- A centrally owned and shared technology stack for Software-Assisted Vehicles (SAVs), including standardized hardware, software interfaces, and safety regulations to reduce costs and ensure interoperability, an open SAV reference architecture and a national high-definition map cloud through public-private partnerships

Talent and Capability Development

- Train and retain a workforce of 30,000+ engineers[33] that specialize in SAVs by 2035
- Centers of Excellence in vehicle software at premier engineering and management institutes, and introduce SAV-focused minor degree programs
- A Global Mobility Tech Visa to attract international talent with streamlined processing and competitive compensation
- Upskill and retain engineers with combined expertise in AI and mechanical engineering by 2035 to support the auto components industry
- Open public-private Centers of Excellence to reskill OEM engineers, integrate AI into undergraduate curricula, and host industry-supported hackathons

Supplier Ecosystem

- Grow the SAV-ready supplier base to over 100 firms[34] across sensors, ECUs, chip design, and AI services
- Two auto-grade semiconductor fabs with a monthly production capacity of 40,000+ wafers[35] under the India Semiconductor Mission to meet domestic demand and potentially create an export surplus

33 Benchmarking against Volkswagen's 10k engineers for 9M cars and scaling down to 0.6M vehicles/year for an Indian OEM (i.e., 660 engineers), taking a 20% cut for in-house engineers, yields 100–120 engineers/ OEM for India's 38-40 OEMs

34 Benchmarking with Germany's SAV-ready suppliers, scaled to India's aspiration of producing 5M+ vehicles/year by 2035; GTAI (Germany Trade & Invest) report titled "Automotive Industry – Germany's Production of 4.1 Million Passenger Cars". October 10 2024.; Meyer Industry Research report titled "TOP 100 Automotive Suppliers Germany 2021"

35 EE Times article titled "ESMC 300-mm Wafer Fab: A Bid to EU's Semiconductor Sovereignty". November 7 2024

Regulatory

- Government decision makers could review standard frameworks for vehicle cybersecurity and over-the-air software updates to align with global regulations
- Government decision makers could seek to form an SAV Regulatory Taskforce under the Ministry of Road Transport and Highways to develop agile and globally aligned standards
- Government decision makers could look at the potential of a fast-track AI patent regime to reduce the patent grant timeline to under 20 months

Market Access and Compliance

- Concessional GST slab or an income-tax deduction on financing costs for components designed or validated using AI e.g., Deep-Learning Surrogates (DLS) to encourage adoption
- "Digital Patent Box" with a lower tax rate for licensed DLS models and AI workflows developed and commercialized in India
- Global AI safety standards integrated into the existing AIS-140 framework to ensure compliance and certify AI-generated components for domestic and international markets
- National Surrogate-Model Certification Sandbox established, e.g., at ARAI Pune, to test and certify AI models for the automotive industry

Key risks

India's aspiration of software vehicles is prone to following risks

●Data ●Market access ●Talent ●Supplier ecosystem ●Regulatory and IT Policy

- **Regulatory misalignment**

  If the automotive sector does not harmonize its cybersecurity and software-update rules with UNECE WP.29 R155/R156 by 2028, Indian SAVs could fail EU/Japan official certifications, shrinking exports[36]

- **Semiconductor shortfall**

  If two auto-grade 28/16nm fabs are not commissioned & global chip procurement lead time continue to remain high (currently >70 weeks), assembly lines can idle for 3-5 quarters, reducing value capture

- **Cyber-trust shock**

  If a major cyber hack occurs before robust cybersecurity compliance is in place, it can crash consumer trust and limit adoption rates.

- **Domestic supplier base stagnation**

  If component suppliers do not innovate quickly enough to develop modular, certified parts, the penetration of SAVs will remain limited - slowing roll-outs and constraining revenue growth

- **Engineering talent gap**

  If only 25-30k of the required 35k-40k SAV engineers are trained or attracted, software cycles may lengthen 6-12 months, trimming value capture from subscription revenues

- **Feature non-democratization risks**

  Unless industry bodies actively democratize and scale Tier 1 and Tier 2 SAV features, adoption could stay far below the 40–50% target for 2035

36 UNECE press release titled "Three landmark UN vehicle regulations enter into force". February 5, 2021

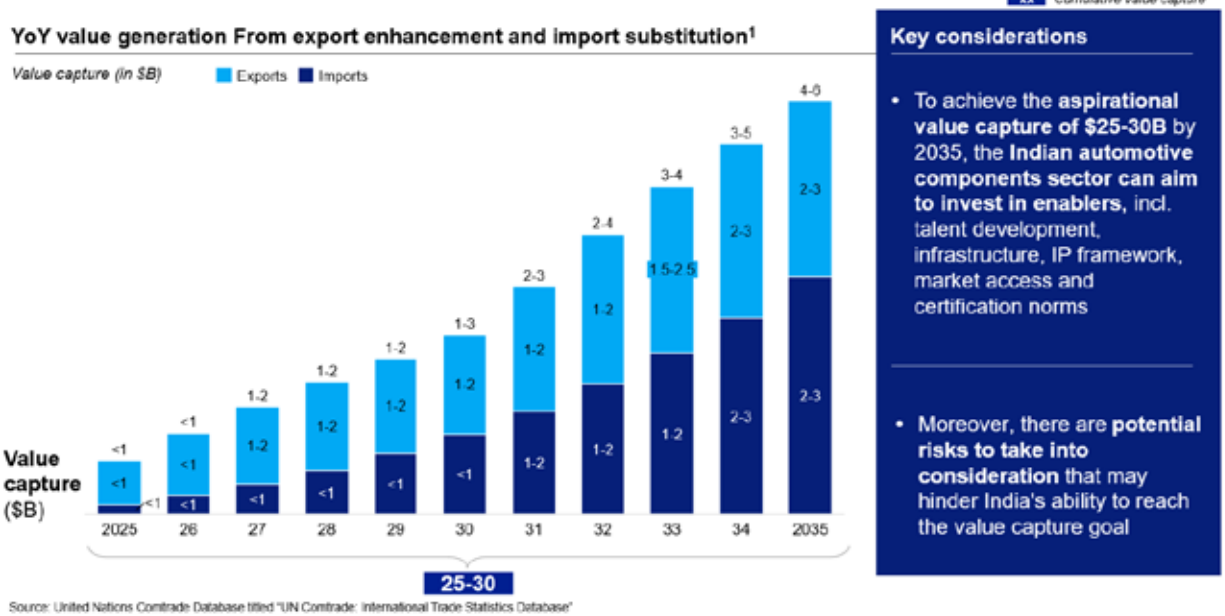
Auto components design

AI-powered models such as Deep-Learning Surrogates (DLS) replicate the behavior of complex physics simulations, enabling near-instantaneous and highly accurate predictions. These models are transforming the R&D value chain, redefining how components are designed, tested, and manufactured. Traditionally, simulating component behavior like aerodynamic drag, thermal stresses, or structural deformation requires extensive physics-based computing that can take hours to days per iteration. Once trained, the AI models perform the simulations in milliseconds, significantly accelerating R&D cycles and enabling more efficient, low-cost innovation.

For India, which currently accounts for 1-2%[37] of the $500 to $550B[29] global automotive parts export market i.e., $7-8B, DLS can be an enabler to increase its share significantly. With automotive parts imports at $6-7B[29] in high-potential areas, there is an opportunity to reduce import dependency by improving domestic design and testing capabilities. AI-led design, including DLS, not only boosts competitiveness by slashing development time and costs but also allows India to lead in high-value, design-driven exports moving beyond assembly and manufacturing. Indian auto components OEMs can potentially capture $25-30B in cumulative value by 2035 with an exit value of $4-6B in 2035 (Exhibit 14).

Exhibit 14

Auto component manufacturers can capture $13-17B in export enhancement and $10-15B in import substitution in cumulative value by 2035



Source: United Nations Comtrade Database titled "UN Comtrade: International Trade Statistics Database"

37 United Nations Comtrade Database titled "UN Comtrade: International Trade Statistics Database"

Potential enablers for consideration

Enablers that enhance skill development, strengthen compliance and improve overall performance could benefit the components sector.

Infrastructure

- Automotive bodies can jointly establish three regional Zero Prototype Labs (ZPLs) in India's key component hubs - Chennai/Tamil Nadu (35% revenue share), Pune/Western belt (33%), and Gurgaon-Manesar (30%). These ZPLs would serve as digital testbeds using AI, digital twins, and virtual simulations to eliminate early physical prototyping. They can reduce development time by 20–25% and costs by 10–30%. While large manufacturers can set up in-house ZPLs, MSMEs and startups will benefit from shared facilities
- Examples of similar lab setups globally include EDAG's Zero Prototype Lab in Wolfsburg[38] (~1,700 m, 7-9 petaflops of compute power, run 4.5-6K parallel simulations) and Porsche's center in Weissach[39] (~2,100 m, 10-12 petaflops of compute power, run 6-8K parallel simulations)
- The labs can be potentially run on a shared access model with access defined across three tiers:
  - → Corporate tier: Paid, high-priority access with dedicated compute and IP security
  - → MSME & startup tier: Subsidized, affordable simulation slots
  - → CoE tier: Open academic access for public R&D and skill-building

Incentives and IP Frameworks

- IP for Deep-Learning Surrogate (DLS) models spans data, model architecture, and digital twin workflows. With significant model training costs, legal protection is key to driving investment. India could strengthen its incentives and IP protection frameworks by creating a fast-track AI patent regime to reduce the current patent grant timeline from 48+ months[40] to less than 18 months, ensuring innovators can secure IP rights swiftly before data or model designs are leaked or copied
- The shorter timeline would close India's "protection gap" with the U.S. (about 23 months, with a 12-month "prioritized" track for digital technologies) and South Korea (standard 16 months)

Compliance

- Physics-Informed & Explainable AI (PI-XAI) means AI models used in vehicles should not only be as accurate as traditional simulations like Computational Fluid Dynamics (CFD) but also follow basic physical laws and clearly explain their predictions. For instance, a 2024 study showed a physics-based AI model could predict battery health with just 0.87% error[41]. But experts highlight that regulators still need clear safety limits and ways to measure uncertainty before certifying these models.

38 EDAG article titled "Zero Prototype Lab" (part of "Reducing time-to-market"). November 21 2023
39 Porsche Newsroom article titled "Driving simulators: Test drive without a test vehicle". May 2 2025
40 Times of India report titled "At over 90k patent filings, highest in 2 decades". January 2024
41 Nature Communications article titled "Physics-informed neural network for lithium-ion battery degradation stable modeling and prognosis," Published May 21, 2024

- To encourage compliance, India could integrate global AI safety standards like ISO/PAS 8800:2024 (for explainability and transparency in vehicle AI) and ISO/ IEC 42001 (for ethical AI management) into its existing AIS-140 framework[42]. This would help suppliers certify AI-generated components for both Indian and global markets. This is in line with Germany's Technischer Über-wachungsverein Süd (TUV SUD) (German technical inspection and certification organization), which already runs ISO 8800-aligned "AI Quality" audits for automotive suppliers[43]
- Setting up a National Surrogate- Model Certification Sandbox (NSCS) at ARAI Pune to test and certify AI models using open datasets, physics checks, and cybersecurity setups, feeding results into the new AIS-XAI approval process.
- The above requirements are not exhaustive; industry organizations could lead the collation of a complete set of relevant global standards and certifications, and ~3 months under its accelerated route for semiconductor and Artificial Intelligence filings

Talent

- Large Indian auto-component manufacturers can build dual learning tracks, micro-credentials in DLS for all R&D engineers, and bootcamps for business-unit heads. This mirrors a global auto components manufacturer's upskilling of 130K+ employees, and AI leadership programs at leading automobile OEMs, which have reached 50K+ managers. Indian automotive organizations can establish 20+ public-private Centers of Excellence (CoEs) hosted in IITs, NITs, IISc, and IIMs/ISB to:
  - → Reskill engineers via semester-long residencies
  - → Embed AI–mechanical modules in undergraduate curricula
  - → Run Formula-Student style hackathons using DLS-only validation, supported by industry datasets and grants
- Draw inspiration from global automobile OEMs that have collaborated with technical universities to foster joint research in AI and autonomous systems, or have focused on research in sensor and AI integration, which helps automotive firms build in-house expertise in surrogate modelling and AI-driven simulation

42 ISO/PAS 8800:2024 functional-safety standard for AI in road vehicles. Published December 2024; ISO/IEC 42001:2023 AI-Management-System standard. Published December 2023

43 TÜV SÜD AI Quality Certification Program (AIQCP) training programme. (2024)

Key risks

India's aspiration to be AI first automotive component manufacturer is prone to risks.

●Data ●Infrastructure ●Talent ●Market access ●Regulatory and IT Policy

- **Certification risk**

  If India auto manufacturers doesn't launch a certification sandbox and align with global AI safety norms, auto parts may miss key EU/US approval windows, causing 1–2 year delays and risking export contracts.

- **Supply chain adoption risk**

  If MSME suppliers can't access "DLS-as-a-service" tools, due to high licensing fees, or limited technical support, overall adoption may remain low, potentially limiting India's potential value capture.

- **AI model integrity risk**

  If physics-informed quality checks and secure update systems aren't in place, even one major prediction error or cyberattack could lead to global recalls and a freeze on using AI-designed parts.

- **Infrastructure gap**

  If the three Zero Prototype Labs aren't set up by 2029 due to funding gaps, validation will shift back to physical testing, slowing time-to-market by 20–30%, potentially eroding value gains.

- **Geopolitical risk**

  If future WTO or India–EU rules require firms to disclose training data for safety audits, & companies see this as a threat to their IP, they may limit model exports, shrinking India's global market access.

WAY FORWARD FOR THE INDUSTRY

The full potential footprint of AI on India's economy is difficult to visualize, and this report offers a starting point. It outlines two levers with two priority areas each, but the same structured approach could be extended to other sectors such as logistics, construction, and retail. Global benchmarks already illustrate the scale of opportunity: the IMF estimates AI could lift global GDP growth significantly over the next decade[44]; the World Economic Forum projects that nearly a quarter of all roles worldwide will change within five years due to AI adoption[45]; and McKinsey research suggests that generative AI alone could contribute more than any single technological wave in recent history[46]. These underline the importance of applying an India-specific perspective to additional sectors to identify use-cases, value pools, and enabling conditions.

Equally, labour transitions would be central to how India adopts AI. International institutions estimate that around 35-40% of jobs worldwide are exposed to AI, with higher exposure in advanced economies and meaningful effects across emerging markets[47]. Projections show that while AI will create many new roles, it will also displace many existing jobs, particularly in clerical, routine, and low-skill segments. For India, the challenge would be twofold: preparing a workforce with advanced digital and AI skills to capture new opportunities, while simultaneously ensuring that those displaced are gainfully employed through reskilling, redeployment, or absorption into other growth sectors of the economy.

Finally, productivity gains and innovation must match market creation to translate into growth. India would need to simultaneously deepen domestic demand and secure stronger participation in global value chains. This will require alignment of industrial and trade policies, particularly as global rulebooks evolve quickly. For instance, the European Union's AI Act will phase in obligations for general-purpose and high-risk AI systems, and new climate-related trade measures such as carbon border adjustments are set to shape market access conditions[48]. How India anticipates and responds to global shifts will influence its competitiveness, its ability to attract investment, and its standing as a credible global partner in the AI economy.

44 IMF working paper titled "The Global Impact of AI: Mind the Gap". April 2025

45 World Economic Forum press release titled "Future of Jobs Report 2023: Up to a Quarter of Jobs Expected to Change in Next Five Years". April 2023

46 McKinsey report titled "The Economic Potential of Generative AI: The Next Productivity Frontier". June 14, 2023

47 IMF blog post titled "AI Will Transform the Global Economy. Let's Make Sure It Benefits Humanity." January 14, 2024

48 Website titled "EU Artificial Intelligence Act | Up-to-date developments and analyses of the EU AI Act." 2025

APPENDIX

Seven Pillars of the IndiaAI Mission[49]

Compute capacity	Establish a federated public infrastructure of high-end GPU clusters and launch AIRAWAT (AI Research Analysis and Workbench). The mission targets deployment of 38k+ GPUs to support national compute requirements
Innovation centre	Develop India-specific foundational models and large language models (LLMs) tailored to Indian languages and domains, advancing IP creation
Datasets platform	Build anonymized, consent-based, interoperable public datasets to fuel model training. This platform underpins innovation, application development, and trusted AI governance
Application development initiative	Build AI solutions for agriculture, healthcare, education, and mobility through targeted pilots and partnerships with industry.
Future skills	Train 50L+ students and professionals through AI curriculum integration, data labs, and new certification programs in higher education
Startup financing	Support 1,000+ AI startups through catalytic funding for deep-tech and AI product innovation
Safe and trusted AI	Create frameworks and toolkits to ensure explainable, ethical, and privacy-preserving AI. This includes audit tools and compliance standards.

49 IndiaAI portal (Government of India initiative)

Glossary

AI: Artificial Intelligence: In this report, AI includes software capabilities such as machine learning, data analytics and hardware-driven automation, such as robotics

GDP: Gross Domestic Product: The total value of all goods and services produced in a country in a given time

BAU: Business as Usual: A scenario where current trends continue without major policy or technology changes

MSME: Micro, Small, and Medium Enterprises: Businesses that are classified based on investment size and number of employees

E2E: End-to-End: A complete process or system that functions seamlessly from start to finish

AA: Account Aggregator: A system that allows secure and consent-based sharing of financial data between institutions

IDMO: India Data Management Office: A body responsible for overseeing non-personal and anonymized data governance in India

DEPA: Data Empowerment and Protection Architecture: A framework enabling users to share personal data securely with consent

RBI: Reserve Bank of India: India's central banking institution that regulates monetary policy and ensures financial stability

RBIH: RBI Innovation Hub: A unit under RBI supporting fintech and technology-led innovations in the financial sector

ReBIT: Reserve Bank Information Technology Private Limited: An RBI-owned tech company managing cybersecurity and IT infrastructure

AML: Anti-Money Laundering: Regulations and systems designed to prevent illegal money transactions and funding sources

GPU: Graphics Processing Unit: A high-performance processor ideal for AI workloads, simulations, and image processing

LLM: Large Language Model: An AI model that understands and generates human-like text based on large datasets

API: Application Programming Interface: A set of tools allowing different software systems to interact and share data

IBA: Indian Bank Association: An industry body that represents and coordinates efforts among Indian banks

IT: Information Technology: The use of systems and computers for processing, storing, and transmitting information

PLI: Production-Linked Incentive: A government scheme offering financial rewards to boost domestic manufacturing output

OEE: Overall Equipment Effectiveness: A measure of how well manufacturing equipment is utilized in terms of time, speed, and quality

ML: Machine Learning: A form of AI where systems learn from data to make predictions or decisions

AGV: Automated Guided Vehicles: Driverless vehicles used in factories to transport materials automatically

OEM: Original Equipment Manufacturer: A company that makes parts or products used in another company's end product

TSN: Time-Sensitive Networking: A networking protocol that ensures timely and reliable data delivery for industrial automation

HPC Cluster: High-Performance Computing Cluster: A network of powerful computers used for complex calculations and AI model training

AICTE: All India Council for Technical Education: The regulatory authority for technical and engineering education in India

Biomarker: A measurable biological indicator (molecule, gene, image, signal) that reliably reflects a normal or pathogenic process or drug response.

Omics is a collective term for large-scale data layers such as genomics (DNA), transcriptomics (RNA), proteomics (proteins), metabolomics (metabolites) and epigenomics.

Genomics: Study of an organism's complete DNA sequence.

Transcriptomics: Analysis of all RNA transcripts in a cell or tissue

Proteomics: Large-scale study of protein expression, structure and interaction.

Metabolomics: Comprehensive profiling of small-molecule metabolites.

Biobank: Organised repository storing biological samples and associated data for research.

FAIR principles: Data management guidelines— Findable, Accessible, Interoperable, Re-usable.

IBDC: Indian Biological Data Centre— national life-science data repository.

INSACOG: Indian SARS-CoV-2 Genomics Consortium— pan-India viral sequencing network.

ABDM: Ayushman Bharat Digital Mission— creates India's national health-data infrastructure.

DALY (Disability-Adjusted Life Year): A composite burden-of-disease metric equal to the sum of Years of Life Lost (YLL) from premature death and Years Lived with Disability (YLD); one DALY represents one healthy year of life lost.

R&D Scientists: Researchers involved in various stages of drug development (discovery to approval)

ANRF: Anusandhan National Research Foundation – India's R&D funding body under the Ministry of Science and Technology

BIRAC: Biotechnology Industry Research Assistance Council, a Government of India agency supporting biotech innovation and startups.

NIH's "All of US" program: A U.S. research initiative collecting diverse health data from over 1 million people to advance precision medicine.

Institution-initiated trials: Clinical research studies led and sponsored by academic or research institutions rather than pharmaceutical companies.

Operation Warp Speed: A U.S. government initiative accelerating COVID-19 vaccine development, manufacturing, and distribution.

SEBI: Securities and Exchange Board of India, the securities market regulator, ensures investor protection and market transparency.

Weighted tax deductions: Tax incentives

allowing companies to deduct multiple of eligible R&D expenses to encourage innovation.

Ramanujan Fellowship: Scheme offering re-entry support to Indian scientists abroad for research in India

Ramalingaswami Fellowship: Fellowship program targeting postdocs in life sciences returning to India

NAMTECH: Finishing-school style institute model focused on deep-tech and job-ready skills

AICTE: Apex regulatory body for technical education in India

OCI-Fellow: Proposed track offering incentives for Overseas Citizens of India to return

HPC Cluster: High-performance computing facility used for large-scale simulation and AI research

Indian Biological Data Centre (IBDC): India's central omics repository, housing genomics and bioinformatics datasets

PPP-adjusted: Purchasing Power Parity–adjusted salary comparisons to international levels

ICH: International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use – sets global drug development guidelines

E2E: ICH guideline on Pharmacovigilance Planning – ensures safety monitoring throughout the drug lifecycle

E9: ICH guideline on Statistical Principles for Clinical Trials – ensures consistency and quality in trial design and data analysis

E17: ICH guideline on Multi-Regional Clinical Trials – provides a framework for conducting global trials efficiently

M2/M8: ICH guidelines for Electronic Standards & Submission Format – ensures standardized digital submissions to regulatory authorities

CDSCO: Central Drugs Standard Control Organization – India's national drug regulatory body

GCP: Good Clinical Practice – international standard for ethical and scientific quality in clinical trials

Data Exclusivity: A legal right preventing generic manufacturers from referencing an innovator's clinical data for a defined period

Hatch-Waxman Act: U.S. legislation that grants data exclusivity of 5–12 years for new drugs, protecting clinical trial data

ANRF: Anusandhan National Research Foundation – India's upcoming R&D funding agency to support deep science initiatives

CDSCO NDCT Rules (2019): India's rules for approval of new drugs and clinical trials; enables accelerated pathways and ethics compliance

DPIIT: Department for Promotion of Industry and Internal Trade – involved in IP reforms and innovation policy

Market Access: A Set of policies and incentives that determine how quickly and widely a drug reaches patients at an affordable price

HTAIn: Health Technology Assessment India – evaluates the value-for-money of health technologies

HTA: Health Technology Assessment

– compares clinical efficacy, cost-effectiveness, and equity of medical technologies

DHR: Department of Health Research – nodal body for HTAIn under Ministry of Health

PM-JAY: Pradhan Mantri Jan Arogya Yojana – India's public health insurance scheme covering 550M people

CDSCO: Central Drugs Standard Control Organization – India's national regulatory body for drug approvals

NHA: National Health Authority – implementing agency of PM-JAY

NRDL (China): National Reimbursement Drug List – HTA-based system for national drug price negotiation and reimbursement

NICE (UK): National Institute for Health and Care Excellence – UK's HTA body with legal timelines post EMA approval

EMA: European Medicines Agency – central drug approval authority for the EU

NITI Aayog: Policy think tank of the Government of India – drives long-term policy vision

Made-in-India Innovation Track: Proposed track for public coverage of Indian-developed drugs within 180 days post CDSCO approval

DPIIT: Department for Promotion of Industry and Internal Trade – responsible for Startup India and pharma manufacturing schemes

PLI: Production Linked Incentive – scheme to boost local manufacturing with performance-based incentives

Proprietary AI model: An AI system exclusively owned and trained by an entity, optimized for a specific application like drug discovery

Foundation model: A large-scale pre-trained AI model that can be adapted to multiple downstream tasks

Genome-scale language model: An AI model trained on DNA/RNA sequences to predict the functional impact of mutations and guide target discovery

Nucleotide Transformer: A 2.5B parameter AI model developed by InstaDeep, NVIDIA, and TUM that sets a new benchmark in variant effect prediction

Single-cell foundation model: A model trained on individual cell data (multi-omics) to predict how drugs act across different cell types

scGPT: A "ChatGPT for biology" AI model developed by the Toronto Vector Institute and UHN, trained on millions of single-cell data points

Protein-design model: AI model that predicts 3D protein structures and interactions to help design new drugs

AlphaFold 3: DeepMind's AI model that accurately predicts 3D structures and interactions of proteins and small molecules

Multimodal clinical-prediction model: An AI system that integrates omics, EHR, and phenotype data to guide clinical trial inclusion and adverse event forecasting

Bridge2AI: U.S. NIH initiative to develop AI-ready health datasets for training multimodal biomedical foundation models

India Omics Commons Sandbox: Proposed national platform to house diverse omics datasets for AI model development

SAV (Software Assisted Vehicle): A vehicle with embedded software capabilities,

including smart features like predictive maintenance, OTA updates, and data services

OTA (Over-the-Air): Wireless delivery of software updates or patches to a vehicle's system without requiring service center visits

Modular Components: Vehicle parts designed to be independently upgraded, replaced, or certified

Certified Components: Parts that meet standardized safety, quality, and performance benchmarks set by regulatory bodies

ECU (Electronic Control Unit): Embedded systems in vehicles that control electrical subsystems like braking, engine, and infotainment

ISM (India Semiconductor Mission): A government initiative to build a comprehensive semiconductor ecosystem in India

28nm / 16nm: Semiconductor process nodes indicating the transistor size used in chip fabrication; 28nm/16nm are common for automotive-grade chips

Wafers per Month (WPM): Unit of fab output; indicates how many silicon wafers can be produced each month

Brownfield Fab: A semiconductor plant built on an existing industrial site, often through upgrades or repurposing

Greenfield Fab: A new chip manufacturing facility built from scratch

CHIPS and Science Act: A U.S. federal law enacted in 2022 that allocates $52 billion to promote domestic semiconductor manufacturing

SMIC (Semiconductor Manufacturing International Corporation): China's largest chipmaker, known for strategic investment in 28nm and 40nm auto chips

ACMA: Automotive Component Manufacturers Association of India; apex body for India's auto component suppliers

SIAM: Society of Indian Automobile Manufacturers; works on policy and technical issues affecting Indian OEMs

ARAI: Automotive Research Association of India; certifies automotive components and systems

BIS: Bureau of Indian Standards; national standards body responsible for setting quality norms across sectors

ISMC: International Semiconductor Consortium, a public-private partnership aiming to establish fabs in India

SAV: Software-Assisted Vehicle; vehicles integrated with software-based features like infotainment, diagnostics, and driver assistance "Intelligent and Connected Vehicles

Cyber-Physical System (ICV CPS): Vehicles embedded with AI, sensors, and communication tech to interact with infrastructure and other vehicles in real time."

NIC: National Informatics Centre, India's technology backbone for e-governance and digital infrastructure across government bodies.

ISRO: Indian Space Research Organisation, India's national space agency responsible for space missions, satellites, and launch vehicles.

Zero prototype lab: A digital R&D setup where designs are validated entirely through simulations and AI without

building physical prototypes.

Tier 1/2 Suppliers: Automotive component manufacturers directly (Tier 1) or indirectly (Tier 2) supplying parts to OEMs

Validation Cycle: One complete test cycle of a SAV feature (e.g., parking assist) under various simulated conditions

RSU (Roadside Unit): Fixed communication infrastructure that connects vehicles to network and surroundings for real-time data exchange

5G/6G Corridors: High-speed connectivity-enabled roads to support real-time software and V2X (vehicle- to-everything) communication

NATRAX: National Automotive Test Tracks, a state-of- the-art test facility in Indore, India

STPI: Software Technology Parks of India; organization supporting IT/ITES industries with infrastructure and services

American Center for Mobility (ACM): A 500-acre testing site in Michigan, USA, focused on software- defined vehicle technologies

K-City: An 80-acre autonomous driving testbed in South Korea, equipped for smart mobility trials

DLS (Deep Learning Surrogates): AI models that emulate physical simulations to accelerate design and validation of components

OEM (Original Equipment Manufacturer): A company that produces parts and equipment that may be marketed by another manufacturer

CoE (Centre of Excellence): Specialized institutional setups for applied research, talent development, and innovation

AICTE: All India Council for Technical Education – a body for curriculum reforms and engineering standards

Micro-credentials: Short, specialized certifications validating skillsets in niche areas like AI in engineering

Hackathon: A competitive, time-bound innovation challenge to solve real-world problems

Formula-Student: An international student competition to design and race small-scale formula-style cars

Digital twin: A virtual representation of a physical object or system used for simulation, design testing, and monitoring

High-performance computing (HPC): Large-scale computational infrastructure used to train complex AI models and run massive simulations

Patent grant timeline: The time taken from patent filing to final approval and grant of IP rights

AI-priority patent track: A fast-track mechanism for processing patent applications related to artificial intelligence innovations

Model licensing scheme: A framework enabling OEMs or Tier-1 suppliers to license trained AI models or virtual component validations as services

Intellectual property (IP): Legal rights granted over inventions, datasets, models, and processes that are original and provide economic benefit

Ministry of Electronics and Information Technology (MeitY): Indian ministry overseeing digital and AI technology advancement

Department for Promotion of Industry and

Internal Trade (DPIIT): Indian ministry responsible for IP frameworks, industry regulations, and startup innovation policies

PI-XAI: Physics-Informed & Explainable AI — AI models that both obey physical laws and provide interpretable results

CFD: Computational Fluid Dynamics — Traditional physics-based method used to simulate fluid flow and heat transfer in automotive and other systems

ISO/PAS 8800:2024: International standard for transparent and explainable AI systems used in vehicles

ISO/IEC 42001: International standard for ethical and accountable AI management within organizations

AIS-140: Indian Automotive Industry Standard related to Intelligent Transport Systems, including GPS tracking and emergency systems

AIS-XAI: Proposed extension of AIS standards to include explainable AI certifications

TÜV SÜD (Germany): Technical inspection and certification agency offering AI quality audits compliant with international standards

NSCS: National Surrogate-model Certification Sandbox — A proposed setup at ARAI for testing and certifying AI models using open data, physics checks, and cybersecurity

BIS: Bureau of Indian Standards — India's national standards body responsible for standard setting and certification

MHI: Ministry of Heavy Industries — Central ministry responsible for the automotive industry's policy and standards governance

GST (Goods and Services Tax): A unified indirect tax in India levied on the supply of goods and services

Digital Patent Box: A policy regime offering lower tax rates on profits earned from locally developed and licensed IP

CBDT: Central Board of Direct Taxes, responsible for direct tax policy formulation and enforcement

PLI (Production Linked Incentive): A government scheme offering financial incentives based on incremental production and sales

ICE (Internal Combustion Engine): Traditional vehicle engines that run on petrol or diesel

Bureau of Indian Standards (BIS): National standards body responsible for product certification schemes

NITI Aayog: India's apex policy think tank guiding economic and technological policy reforms

Ministry of Heavy Industries (MHI): Nodal ministry for the automotive sector, among others

Digital twin: A virtual representation of a physical object or system used for simulation, design testing, and monitoring

Patent grant timeline: The time taken from patent filing to final approval and grant of IP rights

AI-priority patent track: A fast-track mechanism for processing patent applications related to artificial intelligence innovations

Model licensing scheme: A framework enabling OEMs or Tier-1 suppliers to license trained AI models or virtual component validations as services

Intellectual property (IP): Legal rights granted over inventions, datasets, models, and processes that are original and provide economic benefit

Industry 4.0: The fourth industrial revolution is marked by integration of digital technologies like AI, IoT, and robotics into manufacturing and industry.

Advanced Cyberinfrastructure Coordination Ecosystem-Services & Support (ACCESS): A U.S. initiative providing advanced computing, data, and support services to accelerate scientific research.

NEAT: National Educational Alliance for Technology, a Government of India platform to bring AI-powered learning tools to higher education

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NITI Frontier Tech Hub

THE ONLY WAY TO PREDICT THE FUTURE IS TO CREATE IT...

सत्यमेव जयते

NITI Aayog