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Bridging the Adoption Cliff
An AI Readiness Index and Tiered Roadmap for Indian Logistics

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Abstract

Indian logistics accounts for 7.97 percent of GDP and stands at an inflection point. ESG obligations, geopolitical re-routing of supply chains, and competitive pressure have converged to make artificial intelligence adoption an industry imperative. Yet the imperative tells us nothing about the pathway. How does a sector dominated by MSMEs — whose AI literacy sits five times below that of large enterprises — actually embrace a transition of this magnitude? This paper develops a three-layer mitigation strategy: an AI Readiness Index across six weighted dimensions, an India-versus-comparators Benchmarking Matrix, and a Tiered Adoption Roadmap covering Tier-1 logistics service providers, mid-market firms, MSMEs, and government. China, Brazil, Indonesia, and Germany triangulate India's distinctive position, offering both platform-mediated models of MSME inclusion and, in Germany's case, a cautionary record of what compounds when SME participation is sequenced as an afterthought. The paper's central finding: India's bottleneck is not technology supply but absorptive capacity at the MSME tier. The economies that progressed fastest embedded AI inside platforms MSMEs already used, rather than asking MSMEs to adopt AI directly.

Keywords

AI adoption; logistics; India; readiness framework; cross-country comparison; MSME; absorptive capacity; digital public infrastructure

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Introduction

Indian logistics is a ₹ 24.01 lakh crore industry — 7.97 percent of GDP for 2023–24, per the DPIIT-NCAER joint assessment drawing on primary data from over 3,500 industry stakeholders and secondary data from MOSPI, RBI, and GSTN [1]. This places India ahead of structural peers Brazil (15.5 percent of GDP in 2025) [2] and Indonesia (~14.29 percent in 2024) [3] and approaching the developed-economy benchmark of around 8 percent. The headline number nonetheless conceals a more consequential gap — the digital gap between India's largest logistics service providers and the tens of thousands of MSMEs that move most of its freight.

The case for accelerated AI adoption in Indian logistics has been made from several directions. The ESG case is genuine: route optimisation, predictive maintenance, and load consolidation each cut emissions intensity, and Indian logistics — heavily road-dependent and fragmented at the operator level — carries structural slack that AI is well placed to capture. The geopolitical case is sharper: as global supply chains decouple and re-route, India's positioning depends on logistics performance that matches the operational sophistication of its peers. The competitive case is the most immediate: e-commerce, manufacturing exports, and inbound investment depend on a logistics layer that keeps pace with the digital intensity of the customers it serves. Yet none of this tells us how the transition actually happens. The imperative-to-pathway gap is the puzzle this paper takes up.

India's AI ecosystem has matured rapidly at the enterprise tier. The NASSCOM AI Adoption Index 2.0 scored India at 2.47 on a four-point scale in 2024, with 87 percent of surveyed firms in the middle stages of "Enthusiast" or "Expert" maturity [4]. The Cabinet-approved IndiaAI Mission (₹ 10,371.92 crore total outlay), operationalised in March 2024 [5], has onboarded over 38,000 GPUs at a subsidised ₹ 65/hour rate, and hosts 5,500+ datasets and 251 AI models on AIKosh [6]. The Union Budget for FY 2025–26 increased MeitY's allocation by 18.64 percent to ₹ 26,026.25 crore, with ₹ 2,000 crore earmarked for the IndiaAI Mission specifically. The Unified Logistics Interface Platform (ULIP), launched under the National Logistics Policy in 2022, crossed 160 crore API transactions by August 2025, integrating 30+ digital systems across 11 ministries [7]. Yet adoption within India remains starkly uneven. AI literacy in small firms stands at 2.4 percent against 12.5 percent in large enterprises — a five-fold gap [8] that defines the central puzzle of this paper. Figure 1 visualises this ***adoption cliff***.

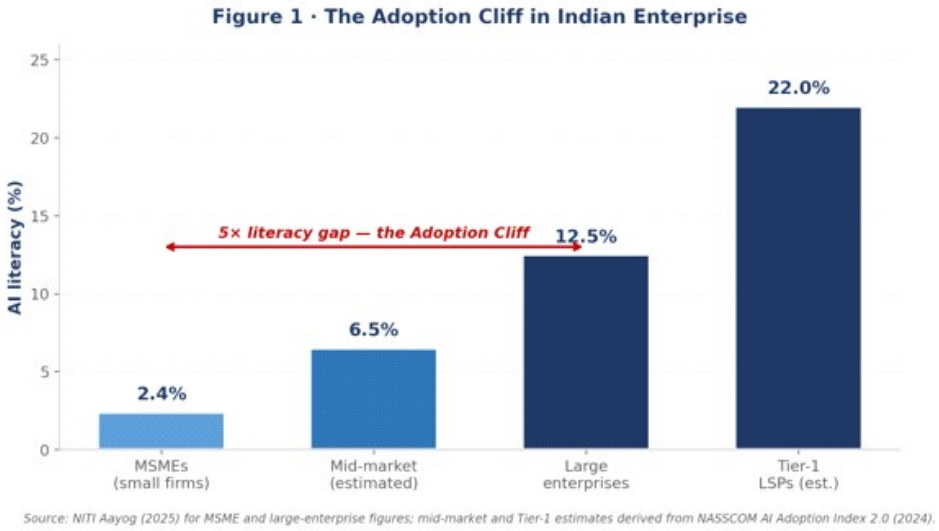

Figure 1. The Adoption Cliff in Indian Enterprise. AI literacy varies by an order of magnitude across firm tiers.

The remainder of the paper proceeds as follows. Section 3 reviews the theoretical literature and positions the contribution. Section 4 sets out the research aim, questions, and methodology. Section 5 presents the results and discussion in five subsections covering the six-dimension challenge framework, the four-country comparison, the Benchmarking Matrix, the AI Readiness Index, and the Tiered Adoption Roadmap. Section 6 concludes.

Literature Review

1. Firm-Level Adoption Theories

The **Technology Acceptance Model** (Davis, 1989) establishes that adoption decisions hinge on perceived usefulness and ease of use. For Indian logistics MSMEs — family-owned firms with limited technical capacity — AI typically scores low on both, even where the underlying tools are objectively useful [9]. The **Unified Theory of Acceptance and Use of Technology 2** (Venkatesh, Thong & Xu, 2012) adds facilitating conditions, social influence, and price value [10]. These matter disproportionately in the Indian MSME context. NASSCOM-Meta data show 59 percent of MSMEs cite budget as the primary AI barrier, 65 percent report an awareness gap, and 72 percent need targeted training [11] — patterns that map directly onto UTAUT2's constructs. The **dynamic capabilities** framework (Teece, 2007) explains why Tier-1 LSPs absorb AI faster than smaller firms: they have institutionalised sensing, seizing, and transforming capabilities that MSMEs lack [12].

2. Absorptive Capacity and Cross-Country Diffusion

Absorptive capacity (Cohen & Levinthal, 1990) is the theoretical lens carrying the heaviest weight in this paper [13]. The core insight — that a firm's ability to recognise, assimilate, and apply new external knowledge depends on prior related knowledge — operates not just at the firm level but, this paper argues, at the *tier* level. The five-fold gap between small-firm and large-enterprise AI literacy is a tier-level absorptive-capacity problem, and a framework designed to address it must operate at the tier level rather than the firm level alone. **Cross-country diffusion theory** (Rogers, 2003; Comin & Hobijn, 2010) grounds the comparator approach: adoption follows S-curves whose slope and ceiling depend on absorption infrastructure, and comparison across economies with different infrastructures reveals which design choices accelerate adoption [14] [15].

3. Contemporary Frameworks and Theoretical Positioning

Two international instruments frame the analysis. The **IMF AI Preparedness Index**, elaborated in the World Bank's *Beyond the AI Divide* study, organises country preparedness across four pillars: digital infrastructure, human capital, innovation and integration, and regulation and ethics [16]. The **Oxford Insights Government AI Readiness Index 2024** ranks 193 countries and flags India's digital public goods (ONDC, Bhashini, ULIP) as "game-changers" under-recognised internationally [17]. The six-dimension framework developed in this paper maps cleanly onto the AIPI pillars while adding the *tier-disaggregation* that country-level indices cannot capture. This is the paper's theoretical contribution: bridging firm-level adoption models (TAM, UTAUT2, dynamic capabilities) and country-level diffusion models (Rogers; Comin & Hobijn; AIPI; GARI) with an instrument that operates at any of three scales — firm, tier, or national.

Methodology

Aim. This paper develops and applies a three-layer mitigation strategy for AI adoption in Indian logistics, grounded in cross-country comparative evidence.

Research Questions.

- **RQ1.** What structural, capability, behavioural, and linguistic barriers constrain AI adoption across the tiers of the Indian logistics industry?
- **RQ2.** What pathways do China, Brazil, Indonesia, and Germany offer for India's adoption journey?
- **RQ3.** How can an AI Readiness Index diagnose readiness gaps at firm, tier, and national levels, and inform a tiered adoption roadmap?

Systematic Literature Review. Databases: Web of Science and Scopus. Search strings followed two tracks: (i) "AI" OR "artificial intelligence" combined

with "logistics" and the name of each comparator country, and (ii) "AI adoption" combined with "emerging markets," "MSME," and "absorptive capacity." Inclusion criteria: 2018–2025, peer-reviewed, English. An initial corpus of approximately 110 articles was screened to 23 retained citations, supplemented by primary policy and statistical sources from authoritative national agencies.

Comparative case studies. Country profiles triangulate across (a) World Bank, OECD, and IMF publications including the AIPI framework; (b) national statistical agencies (DPIIT-NCAER for India, CNT and IBGE for Brazil, BPS-Statistics for Indonesia, Destatis for Germany, NBS for China); (c) industry bodies (NASSCOM, NITI Aayog, Sebrae, BMWE, FAO); and (d) peer-reviewed sectoral literature. Aggregator and blog sources were excluded where primary sources were available.

Limitations. Readiness Index weights are theoretically grounded but not empirically calibrated against firm-level outcomes; this is flagged as a direction for future research. Secondary data quality varies across comparator economies. MSME data in India is comparatively thin, and MSME-related conclusions should be treated as directionally robust rather than precisely measured.

Results and Discussion

1. The Indian AI Adoption Challenge — Six Dimensions

The diagnostic framework organises the Indian AI adoption challenge across six dimensions, each reflecting a binding constraint identified in the empirical literature. Figure 2 plots India's current position on the six axes.

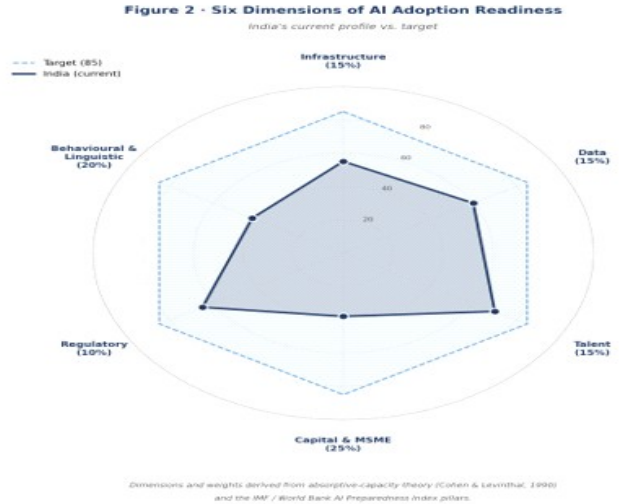

Figure 2. Six-dimension framework with India's current scores. Capital & MSME (38) and Behavioural & Linguistic (42) are the binding constraints.

Infrastructure remains concentrated in metropolitan India. The IndiaAI GPU pool benefits firms with the sophistication to consume compute productively, but cold-chain digitisation, rural connectivity, and last-mile data backhaul are underdeveloped in the Tier-2/3 corridors where MSME logistics operates. **Data** infrastructure is progressing — ULIP's transaction volume is genuine national scale — but fragmentation across modes, states, and participants persists. Quality and interoperability, not volume, remain binding. **Talent** is not a supply problem at the national level; India hosts the world's second-largest AI talent base. The problem is sectoral and tier-wise distribution, with talent flowing to consumer technology and BFSI rather than asset-heavy logistics.

Capital and MSME constraints are, on the evidence, the most binding dimension. Sixty-eight percent of MSMEs find initial AI investment costs prohibitive [11]; working-capital cycles are largely incompatible with three-year ROI horizons. The **regulatory** environment is coordinated — the National Logistics Policy (2022) and LEADS 2024 provide the frame [18] — but DPDP Act implementation and the still-evolving AI regulatory framework create operational uncertainty. **Behavioural and linguistic** barriers combine change-management challenges with an operator-driver workforce that works in vernacular while most AI tools default to English. IndiaAI's foundational-models pillar (Sarvam, Soket, Gnani, Gan, BharatGen) and AI4Bharat address this substrate, but commercial logistics deployment remains early.

2. Cross-Country Comparison — Four Comparator Economies

India sits between two worlds. Its developing-economy peers — with federal political structures, MSME-dominated industry, road-heavy modal mixes, and multilingual workforces — offer lessons from comparable starting conditions. Its developed-economy references offer a different lesson: a record of what compounds when adoption is sequenced poorly. Figure 3 plots the five economies in a development-and-maturity space.

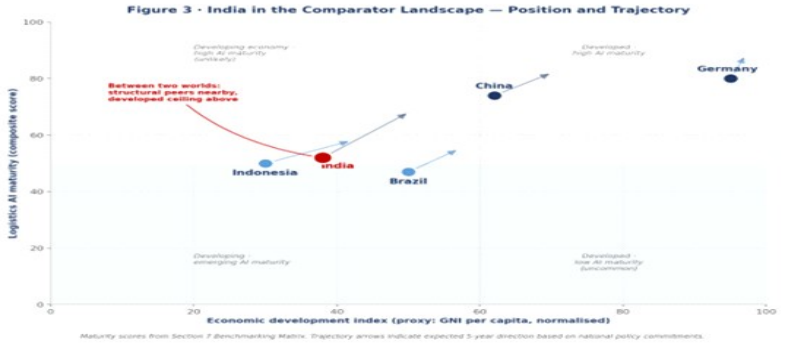

Figure 3. India in the comparator landscape. Trajectory arrows indicate expected five-year direction based on national policy commitments.

China has driven social logistics cost from 18 percent of GDP in 2012 to 14.4 percent in 2023 through 3,286 digital freight platforms coordinating over 8 million trucks and 7.3 million drivers [19]. Waiting times have been compressed from 2–3 days to 8–10 hours, cutting transaction costs by 6–8 percent. JD Logistics runs more than 3,600 warehouses; Cainiao's smart logistics network spans 200 countries. More India-relevant is the **Taobao Villages** model — rural clusters in which MSME producers sell directly through Alibaba's platform, which handles AI-driven demand forecasting, logistics matching, and credit scoring on their behalf. Peer-reviewed analysis covering 335 counties and 16,500+ villages documents a self-organising e-commerce ecosystem that disintermediates traditional rural commerce [20]; the FAO Digital Agriculture Report profiles this as a transferable rural-inclusion template [21]. The lesson for India is platform disintermediation — pulling MSMEs into AI-enabled logistics by embedding the AI in the platform layer rather than expecting MSMEs to deploy it themselves.

Brazil offers the closest analogue to India's federal, MSME-heavy, road-dominant structure — with a worse cost outcome (15.5 percent of GDP in 2025, up from 12 percent in 2019 [2]) and a lower LPI rank (54th). Where Brazilian logistics AI has progressed measurably is in agri-logistics, particularly along the Arco Norte corridor, which handles approximately 38 percent of Brazil's soybean and corn exports. This sectoral concentration is itself a lesson for capital-constrained economies: pick high-ROI corridors and prove the model rather than spreading investment thinly. But Brazil's strongest India-relevant lesson is the **Pix-plus-open-finance** trajectory. Pix, the instant-payments rail launched in 2020, was extended in 2022 with an open finance framework allowing consent-based sharing of transaction data with third-party lenders for MSME creditworthiness assessment. The Innovations for Poverty Action 2024 pilot found that a 4 percent rise in active Pix users corresponds to a 1 percent rise in new banking relationships [22]. The India parallel is precise: UPI is the analogue of Pix, Account Aggregator the analogue of Brazilian open finance, and ONDC an additional layer Brazil does not yet possess.

Indonesia is the comparator whose lessons transfer most directly to India's MSME problem. Its National Logistics Ecosystem (NLE), established by Presidential Instruction No. 5 of 2020, covers 97 percent of sea-cargo and 98 percent of air-cargo traffic across 46 seaports and 6 airports; the associated Sea Toll programme reduced regional price disparities from 14.2 percent to 10.25 percent [23]. Yet Indonesia's LPI rank fell from 46 to 63 between 2018 and 2023, and take-up has been slow with low inter-platform connectivity [24] — platform infrastructure alone is not sufficient; change management and interoperability matter equally. Where Indonesia has succeeded most clearly is in the **platform-mediated MSME aggregator** model.

Gojek's GoStore and GoToko onboard MSMEs into AI-enabled logistics without requiring direct AI adoption; the platform handles route optimisation, demand forecasting, and credit scoring [25]. The Indonesian AI-in-last-mile-logistics market reached USD 1.2 billion in 2024, and J&T Express shipped over 30 billion parcels in 2025 with Indonesian volume up more than 60 percent year-on-year — evidence of the scale at which platform-mediated MSME logistics has been operationalised.

Germany has been working on Industrie 4.0 for fourteen years. Plattform Industrie 4.0 was established in 2011 and now extends into Manufacturing-X, presented at Hannover Messe 2025 [26]. Crucially, Germany did not *ignore* the SME tier. The Mittelstand 4.0 Initiative, launched in 2015, established 26 integrated Competence Centres providing hands-on supervision, demonstration spaces, and structured digital-maturity tools jointly developed with the University of Potsdam and Hasso-Plattner-Institut. By 2020 the network had benefited more than 65,000 SMEs [27], and the complementary Digital Jetzt programme provided dedicated SME digitisation and IT-security grants. And yet — fourteen years in — SMEs still lag. The BMBF reports that 40 percent of German manufacturers cannot find AI-qualified workforce, and peer-reviewed analysis documents that German SMEs face "shortage of qualified specialists, lack of adequate base technologies for Industrie 4.0, and an insufficient digital mindset" [28]. McKinsey's December 2024 Digital Logistics survey confirms the global pattern: large shippers race ahead while lower-revenue firms lag [29]. The German lesson is sobering: even sustained, well-funded SME-inclusion investment does not close the gap when the underlying platform is Tier-1-first by design. Retrofitting SME inclusion is harder than designing for it. Table 1 synthesises the comparative findings.

Country	Top-down lesson	Bottom-up / MSME lesson	What to avoid
China	State-orchestrated digital freight platforms (3,286 platforms nationwide)	Taobao Villages — platform disintermediation enables MSME inclusion	Political-economy reliance on top-down mandates
Brazil	Sectoral concentration in Arco Norte agri-corridor	Pix + open finance → MSME credit formalisation via payments data	Pure infrastructure investment without DPI underneath
Indonesia	NLE digital logistics backbone across 46 seaports + 6 airports	Gojek GoStore/GoToko aggregator-mediated AI for MSMEs	Platform without change management → take-up lags
Germany	Mittelstand 4.0 — 26 centres, 65,000+ SMEs reached	Digital Jetzt SME-specific funding programme	Retrofitting SME inclusion onto Tier-1-first architecture

Table 1. Comparative lessons inventory across the four economies.

3. Benchmarking Matrix

The Benchmarking Matrix applies the six-dimension framework across India and the four comparator economies. Each cell is scored 0–100 against a transparent evidence base: the World Bank LPI 2023 [30], the IMF AIPI, Oxford Insights GARI 2024, NASSCOM's AI Adoption Index 2.0, and the national statistical agencies of each comparator. Figure 4 presents the matrix as a heatmap.

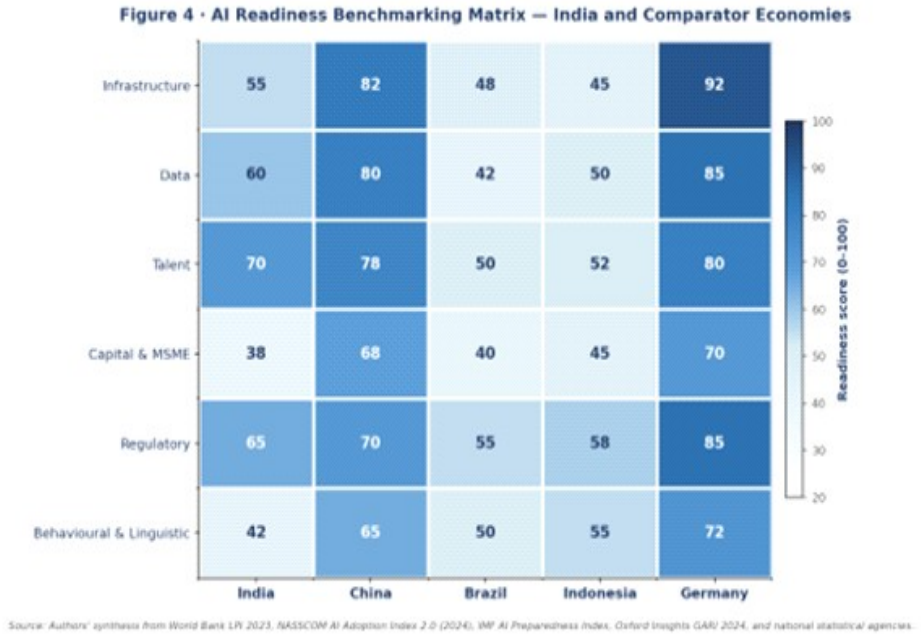

Figure 4. AI Readiness Benchmarking Matrix. Cell colour indicates score intensity (pale to navy = 20 to 100).

Composite (weighted)	India	China	Brazil	Indonesia	Germany
Composite score (0–100)	52	74	47	51	80

Three observations follow. India's composite of 52 places it ahead of Brazil and Indonesia despite shared structural features — policy momentum, talent base, and platform infrastructure (ULIP, IndiaAI) have extracted a measurable lead from a comparable starting position. India's strongest dimensions are Talent (70) and Regulatory (65). India's weakest are Capital & MSME (38) and Behavioural & Linguistic (42), which together carry 45 percent of the composite weight. Closing these two gaps would generate the largest possible composite-score improvement, and is where the Tiered Adoption Roadmap in §5.5 concentrates its prescriptive

force. The Germany gap, quantified at 28 composite points, is not homogeneous — Tier-1 Indian logistics is closer to Germany than the headline gap suggests, but the tier-wise gap explains why the composite does not narrow faster.

4. The AI Readiness Index — Layer 1 of the Strategy

The Readiness Index is a six-dimension instrument with theoretically grounded weights, applicable at firm, tier, or national scale. Weights derive from the literature reviewed in §3 — heaviest weight on absorptive-capacity-adjacent dimensions — and are informed by comparative reference to AIPI overperformer findings.

Dimension	Weight	Theoretical justification
Capital & MSME	25%	Binding constraint from absorptive-capacity literature; corroborated by 59% MSME budget-citation rate
Behavioural & Linguistic	20%	Awareness, trust, and language barriers; UTAUT2 facilitating-conditions construct
Infrastructure	15%	Necessary condition; India's national trajectory improving via IndiaAI and rural connectivity
Data	15%	Necessary condition; ULIP progress reduces relative urgency
Talent	15%	Strong national supply; weight reflects sectoral and tier-wise distribution problem
Regulatory	10%	Coordinating frame already established under NLP 2022

Each dimension decomposes into approximately four indicators (~24 total). Composite scores range 0–100, with sub-scores per dimension permitting diagnostic disaggregation. The Index applies at *firm level* (self-assessment), *tier level* (averaged across Tier-1, mid-market, or MSME populations), and *national level* (the application in §5.3). As a face-validity test, the Index correctly rank-orders the five comparator economies — Germany leading, China close behind, Brazil trailing — the expected ranking under any reasonable specification.

5. From Benchmarking to Roadmap — Layers 2 and 3

The strategy comprises three sequenced layers: diagnostic (the Readiness Index of §5.4), comparative (Benchmarking-to-Levers), and prescriptive (the Tiered Adoption Roadmap). Figure 5 presents the architecture.

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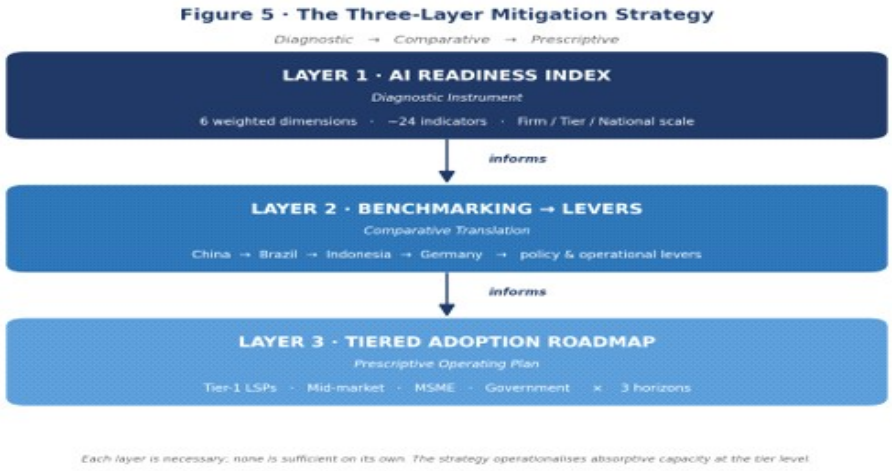

Figure 5. The three-layer mitigation strategy. Each layer informs the next.

The Benchmarking Matrix becomes prescriptive when each cross-country lesson from Table 1 is translated into a specific policy or operational lever for the Indian context.

- **From China.** Twin-track platform infrastructure. Strengthen ULIP as the data backbone and mandate API integration for Tier-1 LSPs above a threshold size. Apply the Taobao-Villages model to MSME logistics: encourage rural commerce aggregators (ONDC participants, FPO-aligned platforms) to embed AI in their MSME-facing tools.
- **From Brazil.** Use the UPI / Account Aggregator / DPI stack as MSME credit-scoring infrastructure for logistics financing. Designate sectoral lighthouse corridors (agri-logistics, e-commerce hub-and-spoke) as first deployment sites.
- **From Indonesia.** Platform-mediated MSME aggregator inclusion via ONDC and Delhivery's MSME services. Invest in change management and inter-platform interoperability alongside the platform itself — the Indonesian record shows platform without change management yields take-up lag.
- **From Germany.** MSME-first design from inception. IndiaAI outputs (foundational models, AIKosh datasets, compute subsidies) must default to MSME-friendly interfaces, vernacular access, and tier-appropriate pricing. The cautionary case is unambiguous: retrofitting SME inclusion onto Tier-1-first architecture does not close the gap, even at scale.

The Tiered Adoption Roadmap operates across four target groups and three horizons.

Tier	Horizon 1 (0–2 yrs)	Horizon 2 (2–5 yrs)	Horizon 3 (5–10 yrs)
Tier-1 LSPs	Move from point-AI to integrated AI platforms; lead on interoperability standards	Cross-LSP data-sharing protocols; federated learning frameworks	Industry-wide predictive supply chains
Mid-market	AI-as-a-service via vertical SaaS; consumption-based pricing	Hybrid capability building — external consumption plus internal teams	Selective autonomous operations in defined use cases
MSME	Vernacular driver and operator apps; platform-embedded AI via aggregators	Aggregator-led AI capability extension; UPI-AA credit tied to performance data	MSME-native AI tools supported by vernacular foundational models
Government	ULIP backbone; vernacular AI public goods; MSME credit-for-digitisation schemes	Sectoral lighthouse corridors funded; LEADS-aligned state-level acceleration	National AI logistics observatory; longitudinal Readiness Index tracking

Table 2. Tiered Adoption Roadmap — four tiers × three horizons.

Conclusion

Indian logistics faces an imperative-to-pathway gap. The case for AI adoption is established by ESG, geopolitical, and competitive considerations alike; the question this paper has addressed is how that transition can actually be made, given the structural characteristics of the Indian industry. The three-layer mitigation strategy — the AI Readiness Index (§5.4), the India-versus-comparators Benchmarking Matrix (§5.3), and the Tiered Adoption Roadmap (§5.5) — is the paper's principal contribution.

The central finding is that India's adoption bottleneck is not technology supply but absorptive capacity at the MSME tier. The comparator economies that progressed fastest did so by ***channelling AI through platforms MSMEs already trust*** — China's Taobao Villages from the bottom up, Indonesia's Gojek aggregator platforms, and Brazil's Pix-plus-open-finance stack from the platform layer down — rather than by asking MSMEs to adopt AI as a standalone capability. Germany's fourteen-year Industrie 4.0 journey, despite substantial dedicated SME investment, illustrates the cost of sequencing SME participation as a follow-on. India's pathway forward is uniquely defined by the absorptive-capacity gap at the MSME tier and by the digital public infrastructure (ULIP, IndiaAI, ONDC, UPI, Account Aggregator, Bhashini) already being built to address it. The window to design MSME-first is now.

Future research will pursue three threads: empirical validation of the Readiness Index against firm-level adoption outcomes with longitudinal weight

calibration; sectoral specialisation of the framework across cold chain, e-commerce, port logistics, and agri-logistics; and longitudinal tracking of the Index with re-runs in 2027 and 2030 to measure whether §5.5's prescriptive levers produce the predicted improvements. Cross-country portability to other large emerging economies with substantial tier heterogeneity is a natural extension.

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