Digital transformation: India's journey to Industry 4.0 excellence

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Contents

Executive summary

India's journey toward Industry 4.0 excellence is driven by digital transformation, which is reshaping the business landscape and offering unprecedented growth opportunities for manufacturing firms and MSMEs. Embracing digital technologies allows these enterprises to optimize operations, deliver enhanced customer experiences, and stay competitive in an increasingly globalized market.

Customer-centric growth has become a pivotal focus, with businesses adopting data-driven strategies to personalize offerings, streamline operations, and create new business models. In the digital age, customers expect convenience, personalization, and seamless interactions, prompting manufacturers and MSMEs to embrace digital tools and analytics to remain relevant and competitive.

Digital manufacturing is powering industrial innovation by integrating smart technologies, automation, and predictive maintenance, leading to cost optimization and yield improvements. Sectors such as automotive, electronics, and pharmaceuticals are leading the way in leveraging these technologies for operational excellence.
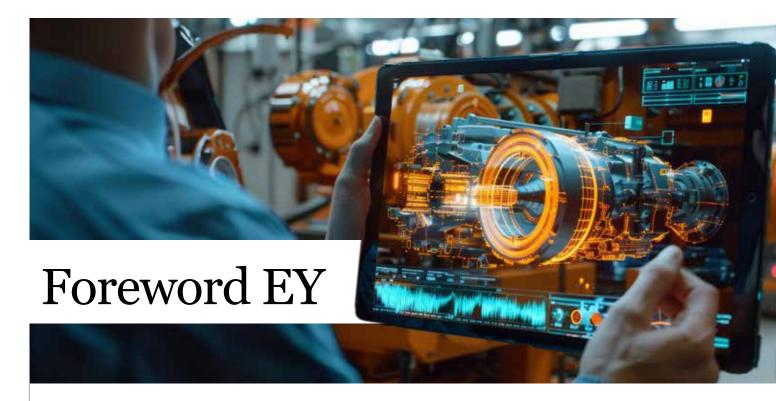
However, adopting digital tools brings challenges, particularly in cybersecurity, where robust defenses are needed to protect operational and informational systems. Advanced threat detection, compliance with regulatory standards, and the implementation of Zero Trust architectures are crucial to building resilience and safeguarding data.

The rise of generative AI is transforming industries by enabling new ways to harness data, drive innovation, and improve decision-making processes. The growth of AI-driven insights is expected to fuel the next wave of digital transformation, particularly in knowledge work and personalized customer interactions.

For MSMEs and start-ups, digital transformation is imperative, with IoT, cloud computing, blockchain, and 3D printing playing a significant role in shaping the future of manufacturing. Government initiatives, skill development programs, and partnerships with tech providers are key enablers of this transformation, though challenges such as limited budgets and resistance to change remain.

Key takeaways:

1 Adopt a customer-first mindset, leveraging data to enhance personalization

2 Invest in digital manufacturing technologies to improve efficiency and quality

3 Strengthen cybersecurity measures to protect critical assets

4 Utilize AI and analytics to unlock actionable insights and drive innovation

5 Collaborate with governments and start-ups to foster growth and digitalization

Foreword EY

In an era defined by rapid technological advancements and shifting global dynamics, digital transformation has become more than just an aspiration—it is an imperative for businesses seeking sustained growth and competitiveness. India's journey toward Industry 4.0 excellence is a testament to the power of innovation, strategic collaboration, and a forward-thinking approach to technology adoption.

As a trusted advisor to enterprises navigating this transformation, we have witnessed firsthand the impact of digital technologies in revolutionizing industries, enhancing operational efficiency, and unlocking new opportunities for value creation. From automation and AI-driven insights to cybersecurity and digital manufacturing, businesses that embrace these shifts are not only future-proofing their operations but also positioning themselves as industry leaders.

For MSMEs and large enterprises alike, the road to digital maturity presents both opportunities and challenges. Addressing key enablers such as customer-centric growth, data-driven decision-making, and workforce upskilling will be critical to ensuring a seamless transition to Industry 4.0. Furthermore, partnerships between businesses, technology providers, and policymakers will play a pivotal role in accelerating this transformation at scale.
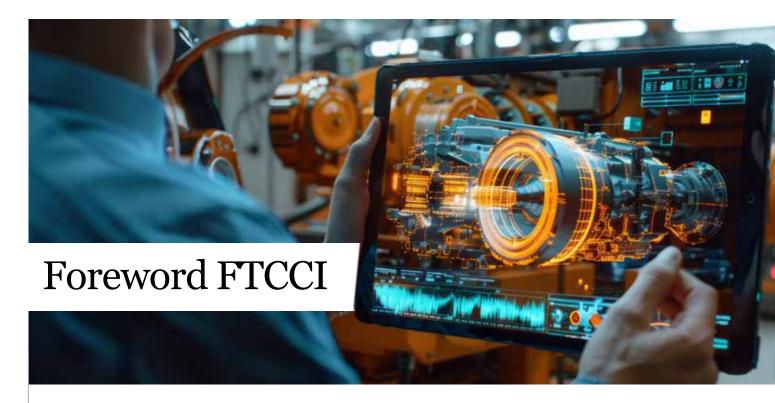
This publication serves as a framework for organizations looking to harness the full potential of digital technologies to drive meaningful innovation and long-term impact. Through a structured approach, it provides insights into best practices, strategic imperatives, and real-world case studies that illustrate how businesses can successfully navigate their digital transformation journey.

As we embark on this transformative path together, I encourage industry leaders to take bold, decisive steps in integrating digital capabilities into their core strategies. The future belongs to those who not only embrace change but lead it. By fostering a culture of innovation, investing in the right digital tools, and strengthening collaborative ecosystems, businesses can pave the way for a smarter, more connected, and sustainable industrial future.

Anirban Mukherjee

Partner, Risk Consulting

Foreword FTCCI

As the world accelerates into the era of Industry 4.0, we stand at the threshold of a profound transformation. Digital technologies are not just enhancing business processes—they are revolutionizing the very core of industries across the globe. The Federation of Telangana Chambers of Commerce and Industry (FTCCI) is proud to present this Thought Leadership White Paper on Digital Transformation and Industry 4.0, in partnership with EY. The White Paper is a comprehensive exploration of how these emerging technologies are shaping the future of business in Telangana and beyond.

In Telangana, we are witnessing an exciting convergence of digital innovation and industrial growth. From smart manufacturing to data-driven decision-making, the adoption of Industry 4.0 technologies, such as artificial intelligence, Internet of Things (IoT), automation, and big data & AI is enabling businesses to improve efficiency, enhance product quality, and create new value propositions. However, this transformation also brings forth challenges—ranging from the need for skilled workforce development to the integration of complex systems across traditional industries.

This White Paper offers a strategic framework for businesses to navigate this digital revolution. Through insightful case studies, industry perspectives, and expert analysis, it provides actionable recommendations for businesses of all sizes to adopt, integrate, and scale digital solutions effectively.

At FTCCI, we believe that the future of Telangana's industrial landscape depends on our collective ability to embrace technological change and foster an ecosystem that encourages innovation, collaboration, and investment. The ICT Committee at FTCCI has been working relentlessly for collaboration with all stake holders towards this goal. This paper aims to equip business leaders, entrepreneurs, and policymakers with the knowledge needed to accelerate digital transformation, unlock new opportunities, and position Telangana as a global hub for Industry 4.0.

Dr. Suresh Singhal

President, FTCCI

I congratulate the FTCCI ICT Committee and EY for coming up with this thought leadership whitepaper. It is a great framework to achieve the goal of accelerating digital transformation and making our MSMEs competitive.

K Mohan Raidu
Managing Director, Informatics India
Chair, ICT Committee, FTCCI

DeepTech and emerging technologies are revolutionizing digital manufacturing and MSMEs—driving intelligent automation, precision, and scalability for a future-ready economy.

Bala Peddigari
Chief Innovation Officer
Technology, Software and Services
Business Group, TCS
Co-Chair, ICT Committee, FTCCI

FTCCI is uniquely positioned to collaborate with policymakers, start-ups and ecosystem partners to unlock the full potential of digital transformation. The experience of the traditional industry, clubbed with the agility of the start-ups, can be a game changer.

Pankaj Diwan
Founder, Idealabs FutureTech Ventures
Co-Chair, ICT Committee, FTCCI

Digitization, decarbonization and automation will, in my opinion, be the key pillars of transformation for all industries. Affordable solutions are needed to drive quick adoption and help in achieve the objectives of Industry 4.0 transformation, especially for SMEs. A lot of start-ups have emerged in this burgeoning space over the last few years as more industry owners wake up to this reality.

CV Anirudh Rao
Director, CV Infracon
Co-Chair, ICT Committee, FTCCI

1 | Introduction

Overview of accelerating growth and innovation

In today's fast-paced business environment, innovation serves as the driving force behind growth and prosperity for enterprises. Recognizing this, a significant 84% of CEOs acknowledge the threat of digital disruption[1], yet fewer than half possess a formal strategy to navigate the digital future. Innovation is not left to chance; it is a deliberate process aimed at creating new growth avenues and ensuring sustained success.

A successful innovation strategy involves a balanced portfolio that combines incremental improvements with radical, disruptive changes. Companies that master innovation often outperform their peers, delivering superior returns to shareholders and offering tangible benefits to customers, partners and employees. The innovation spectrum includes sustaining innovation, which enhances existing products and services; evolutionary innovation, which enters adjacent markets to foster new growth; and disruptive innovation, which creates entirely new markets and business models, altering the competitive landscape.
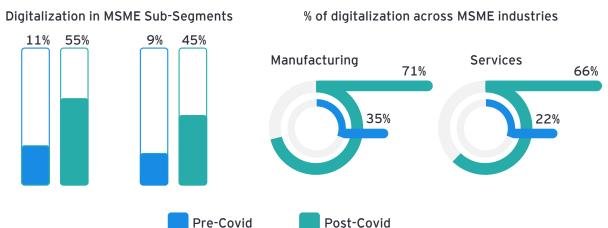
Despite these benefits, many businesses remain within their established areas of expertise, excelling at core functions but showing reluctance to embrace change. This hesitancy often stems from a lack of expertise and a clear vision, which stand as critical barriers to achieving the next level of innovation.

A prime example of successful innovation is the collaboration between Publicis Sapient and Microsoft, which led to the creation of, AGTB, the world's first fully digital trade finance bank, leveraging Microsoft Azure technology. Another case is the development of FacePass for Miral's Yas Island, which introduced contactless customer experiences and set a new standard for disruptive innovation in the hospitality and entertainment industry.[2]

Innovation is not optional; it is a necessity for growth. As the pace of change accelerates, businesses must embrace innovation to remain competitive. By fostering a culture of innovation, investing in technology, and engaging in strategic collaborations, companies can secure their position in the market and drive future success.

The role of digital transformation in manufacturing and MSMEs[3]

Traction in digitalisation seen across MSME segments

Digitalization in MSME Sub-Segments

11%   55%   9%   45%

% of digitalization across MSME industries

Manufacturing   Services

71%   66%

35%   22%

■ Pre-Covid   ■ Post-Covid

The manufacturing sector is a cornerstone of the Indian economy, spurring innovation, employment, and growth. It accounts for ~17% of India's GDP, 60% of exports and 20% of capital investment, and it plays a crucial role in job creation. Yet, technological advancements and global competition have intensified pressure, and the headroom for digital adoption in the sector promises future growth. Digital transformation has become essential for enhancing competitiveness, optimizing operations, and unlocking new opportunities for growth. By integrating technologies such as the IoT, AI, machine learning, and advanced analytics, businesses can streamline processes, enhance quality, reduce time-to-market and offer personalized products.

MSMEs are a critical portion of India's economy, driving significant breadth to trade, services and manufacturing sectors. A healthy MSME sector is critical for job creation and also for the success of Make in India strategy. India has around 63 million SMEs which have generated 11 crore jobs in the economy (22% of the jobs in India). MSMEs contribute to around 30% to India's GDP, making this a critical component of the economy. The adoption of technology and digital is quite low in India. For example, a survey by India SME Forum indicates that 70% of the MSMEs lack awareness of digital tools.

Digital transformation has significantly impacted manufacturing through Industry 4.0, the fourth industrial revolution. This era is marked by the fusion of physical, digital, and biological technologies. Smart factories with connected devices enable real-time communication, self-optimization, and greater flexibility, allowing manufacturers to meet changing customer demands efficiently. For MSMEs, digital tools like e-commerce platforms and CRM systems open doors to global markets, enhance customer experiences and create efficient supply chains. It has been observed that small businesses adopting digital technologies expect four times better revenues than other small businesses operating in a similar business environment. Also, 72% of the small businesses have increased the usage of digital tools during COVID-19.[6]

Despite its benefits, digital transformation poses challenges, especially for resource-constrained MSMEs. Concerns about costs, cybersecurity and skill gaps are common barriers. A strategic approach is crucial, starting with an assessment of current digital maturity and a clear vision for the future. Prioritizing investments, fostering a culture of innovation and upskilling employees are key steps. Collaborating with technology partners can also provide expertise, access to cutting-edge tools, and best practices, accelerating the transformation journey.

The following sections in this document indicate key trends which impact the adoption of digital technologies in India with a specific focus on manufacturing and MSME sector.

[1]Accelerating-Growth-Through-Innovation-2.pdf
[2]Accelerating-Growth-Through-Innovation-2.pdf
[3]7500.pdf
[4]IBEF – Tech based solutions for Indian MSME Landscape - https://www.ibef.org/blogs/tech-based-solutions-to-empower-the-indian-msme-landscape
[5]MSMEs and Digital Technology: New pillars of the Indian Economy - https://www.crn.in/columns/msmes-and-digital-technology-new-pillars-of-the-indian-economy/
[6]Digital Safety Net Helps Small Businesses Survive During COVID-19 - https://connectedcouncil.org/digital-safety-net-helps-small-businesses-survive-during-covid-19/

2 Customer-centric growth in the digital era: A paradigm shift

Key trends in driving digital growth

> **1. Removing barriers for a fairer digital marketing space**

Digital marketing has traditionally been dominated by large enterprises with substantial budgets and resources. However, recent advancements in technology and the proliferation of accessible digital tools have democratized the marketing landscape, enabling smaller businesses to compete on a more level-playing field. This shift is driven by several factors:

- Sachet-sized advertising platforms: Social media platforms such as Facebook, YouTube, Instagram, and LinkedIn offer sachet-sized and pay as you use advertising solutions that allow small businesses to reach targeted audiences without breaking the bank. This enables firms to make small investments in marketing and visibility through focused targeting, which was difficult in the era of billboards, newspaper ads and signages.

- Automation tools: Marketing automation platforms such as HubSpot, Mailchimp, and Marketo provide scalable solutions for managing campaigns, nurturing leads, and analyzing performance. These tools are easy to implement, intuitive to adopt and have less upfront investments, which enables manufacturing and MSMEs to adopt, experiment and scale basis their appetite for investment.

- Data accessibility: The availability of data analytics tools (e.g., Google Analytics, SEMrush) empowers businesses of all sizes to make informed decisions based on real-time insights.

Key strategies for success

To take full advantage of this level-playing field, businesses should focus on the following strategies:

a. **Microtargeting and niche audiences**
   Instead of trying to appeal to broad demographics, businesses should identify and target niche audiences that align closely with their offerings. By leveraging advanced targeting capabilities provided by digital platforms, even small businesses can achieve high engagement rates and conversion metrics.

b. **Content-driven marketing**
   Content remains king in the digital age. High-quality, relevant content—whether it is blog posts, videos, or social media updates—can help establish thought leadership, build trust and foster long-term relationships with customers. Businesses should invest in creating valuable content tailored to their audience's needs and preferences.

   With the advent of Generative AI (GenAI), content creation has become more accessible and efficient than ever before. 40% of Generative AI (GenAI) solutions will be multimodal (text, image, audio and video) by 2027, up from 1% in 2023, according to Gartner, Inc.[7]

   Tools such as GPT-powered platforms can generate engaging articles, social media captions, email campaigns, and even video scripts within minutes, saving businesses significant time and resources. For example, a small e-commerce brand could use GenAI to create personalized product descriptions at scale or draft SEO-optimized blog posts that resonate with its target audience. By automating repetitive tasks, marketers can focus on strategy and creativity, ensuring that the final output aligns perfectly with their goals while maintaining authenticity.

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[7]Gartner Predicts 40% of Generative AI Solutions Will Be Multimodal By 2027
[8]IBEF – Tech based solutions for Indian MSME Landscape - https://www.ibef.org/blogs/tech-based-solutions-to-empower-the-indian-msme-landscape
[9]https://softlinkglobal.com/how-saas-can-help-the-indian-logistics-msme-sector/#:~:text=Correspondingly%2C%20India's%20logistics%20sector%20is,to%20start%20and%20scale%20up

c. **Agile campaign management**
    The ability to quickly adapt and iterate marketing campaigns based on performance data is crucial. Small businesses should adopt agile methodologies, using A/B testing and continuous optimization to refine their strategies and maximize ROI.

2. Growth of experience and convenience

Consumer expectations have shifted dramatically over the past decade. Today's customers prioritize seamless experiences and unparalleled convenience when interacting with brands. From intuitive user interfaces to frictionless checkout processes, every touchpoint matters. Companies that excel in delivering exceptional experiences and convenience are seeing significant gains in customer loyalty and market share.

Drivers of change

Several factors contribute to the growing emphasis on experience and convenience:

- Mobile-first mindset: With mobile devices accounting for most of the online traffic, businesses must ensure their websites and apps are optimized for mobile users. Especially for MSMEs, the rise of Indian start-ups has helped drive adoption across CRM, customer services, credit assessment, accounting products, social commerce platforms and Cloud service providers, which are providing India and MSME specific offerings.[8]

- Omnichannel integration: Customers expect consistent experiences across multiple channels, including physical stores, e-commerce platforms, social media and customer service portals.

- Instant gratification: Fast shipping, easy returns and instant access to information are now considered standard practices rather than differentiators. With the rise of Indian logistics as a service player, these services can be enabled for firms across sectors and specifically for the MSME sector.[9]

Key strategies for success

Businesses aiming to enhance experience and convenience should consider the following approaches:

a. **Seamless user journeys**
    Mapping out the entire customer journey—from discovery to purchase and post-purchase support—is essential. Identifying pain points and eliminating barriers can create smooth, enjoyable interactions at every stage.

A major example of this is the Unified Payments Interface (UPI), which has transformed digital transactions in India. By enabling instant, secure, and hassle-free payments, UPI has significantly improved the checkout experience for both large e-commerce platforms and small businesses. For instance:

- E-commerce integration: Platforms like Flipkart and Amazon India have integrated UPI-based payment options such as Google Pay, PhonePe, and BHIM, allowing customers to complete purchases with just a few clicks without entering cumbersome card details or net banking credentials.

- Grocery retail transformation: Reliance JioMart's adoption of UPI has streamlined payments for grocery deliveries, helping first-time digital shoppers onboard seamlessly.

- Support for small businesses: Kirana stores widely adopted UPI QR codes during the pandemic, enabling contactless payments and enhancing customer convenience.

By eliminating payment friction, UPI has boosted conversion rates and customer satisfaction, making it a model for seamless digital transactions across industries.

b. **Personalized recommendations**
    AI-powered recommendation engines have redefined customer engagement by offering tailored products and content suggestions. Companies like Netflix and Amazon use advanced algorithms to analyze user behavior, driving satisfaction and retention.

Beyond these giants, the rise of open-source solutions has made personalization accessible to businesses of all sizes. Platforms like Odoo, Magento, and Drupal provide flexible, cost-effective tools for implementing recommendation systems:

- Retail customization: Magento's open-source eCommerce platform allows retailers to integrate AI-driven product recommendations based on browsing behavior and purchase history, creating a more relevant shopping experience.

- Content personalization: Drupal's modular framework enables content-heavy websites to deliver personalized content streams to users.

These open-source ecosystems reduce costs, encourage innovation, and empower even small businesses to compete with industry leaders in delivering hyper-personalized experiences.

c. Investment in technology
Adopting emerging can redefine customer engagement and set brands apart. Innovations such as augmented reality (AR), virtual try-ons, and AI-powered chatbots are transforming how customers interact with products and services:

- AR and virtual try-ons: Brands like Lenskart and Nykaa leverage AR to allow customers to try on glasses or makeup virtually, reducing purchase hesitation.

- AI chatbots: Businesses integrate conversational AI to provide instant support, enhancing service efficiency and customer satisfaction.

3. New business models for customers

The rise of digital technologies has led to innovative business models that cater directly to evolving consumer demands. Companies are moving beyond traditional commerce paradigms by adopting approaches that offer flexibility, accessibility, and enhanced customer experiences.

Emerging models shaping the digital economy

a. Raise of multi-entity digital platforms
Multi-entity digital platforms, such as the ONDC, are transforming how businesses operate by fostering inclusivity and reducing dependency on centralized e-commerce giants. ONDC's open architecture enables seamless interoperability between buyers, sellers and service providers, democratizing access to digital commerce for businesses of all sizes.

For MSMEs, this model eliminates entry barriers, allowing them to compete on a level-playing field with established brands. By providing access to a wider customer base without the need for significant investments in proprietary platforms, ONDC empowers small businesses to scale efficiently. Additionally, the decentralized nature of such platforms ensures:

- Fairer revenue distribution with lower commission fees

- Greater control over branding and customer relationships

- Enhanced supply chain transparency to improve operational efficiency

Across sectors, ONDC is driving innovation, enhancing supply chain transparency, and enabling a more equitable digital ecosystem that prioritizes collaboration over monopolization.

b. Pay-as-a-service model
Today, most digital platforms offer Pay-as-a-service and freemium models, allowing businesses to experiment with technology before committing to full-scale adoption. This model is widely used across industries, including:

- Streaming services and hyperscalers that provide consumption-based pricing

- E-commerce and SaaS platforms offering tiered services

- Backend functional platforms that charge based on usage

For MSMEs, freemium models provide a means of experimenting with the technology. Freemium models offer basic versions of products or services for free while charging for premium features. Many of these models fit to the requirement of MSMEs.

c. Direct-to-Consumer (DTC)
By bypassing intermediaries and selling directly to consumers, brands can maintain greater control over pricing, branding and customer relationships. DTC pioneers like Warby Parker and Casper have disrupted industries once dominated by established players. With the raise of e-commerce and quick commerce models in India, DTC has now become one of the key consumer expectations. Increasingly, manufacturing companies are focusing on DTC to drive profitable growth by disintermediating their channels and monetizing the strength of their brands.

The DTC model has significantly empowered MSMEs by enabling direct customer interactions, which provide unfiltered feedback to refine products and services. For example, a local artisanal pickle brand can use customer reviews to improve recipes or packaging, ensuring a better market fit. Additionally, the rise of Logistics as a Service (LaaS) players like Delhivery and Shadowfax has made it easier for MSMEs to deliver products directly to customers' doorsteps, even in remote areas. This eliminates the need for costly warehousing or logistics setups, allowing small businesses to focus on quality and innovation. By combining direct feedback with efficient delivery systems, MSMEs can enhance customer satisfaction, build trust and strengthen their brand reputation, driving sustainable growth while maintaining control over pricing and customer relationships.

Key strategies for success

To implement successful new business models, companies should:

- Focus on value proposition: Clearly articulate the unique benefits of your offering to justify subscription fees or premium upgrades and Generative AI (GenAI) makes this seamless while driving traffic through SEO-driven content. For example, a fitness app can use GenAI to create blogs on "benefits of personalized workout plans," optimized with keywords like "custom fitness solutions," enhancing visibility and educating customers about its unique advantages. Similarly, SEO empowers MSMEs to compete effectively despite limited budgets. A Mumbai-based bakery boosted online orders by targeting long-tail keywords like "best homemade cakes in Mumbai," while a Kerala-based spice seller ranked higher using tags like "authentic organic spices online." By combining GenAI for consistent, high-quality content creation with strategic tagging, meta descriptions and structured data, businesses can improve search rankings, attract targeted audiences, and build trust. This dual approach drives disproportionate traffic, boosts conversions, and fosters long-term customer loyalty without significant ad spend.

- Build strong communities: This includes engaging customers through exclusive content, events, and loyalty programs to create a sense of belonging. The rise of influencers on social media has amplified community-driven sales, especially for traditional and MSME brands. For example, Ayurveda-based product lines like Patanjali and Forest Essentials have thrived by collaborating with influencers who resonate with India's cultural heritage. These influencers share authentic stories about Ayurvedic ingredients, fostering trust among health-conscious consumers. Similarly, micro-influencers are helping rural artisans showcase handmade goods, creating emotional connections with buyers. Such collaborations build loyal communities while preserving traditional values.

- Iterate based on feedback: Continuously gather and analyze customer feedback to refine your model and address unmet needs. For instance, Zomato has iteratively improved its app features based on AI-summarized user complaints about delivery times. By automating feedback analysis, companies save time and ensure iterative improvements align closely with customer expectations, enhancing satisfaction and retention.

What this means for traditional and MSME companies

Customer-centric growth represents a strategic shift where businesses prioritize customer needs and preferences. For India's diverse and rapidly evolving market, this approach is essential for traditional businesses and Micro, Small, and Medium Enterprises (MSMEs) to remain competitive amid digital advancements and changing consumer expectations.

1 Understanding market dynamics
India's consumer base is diverse, with varying cultural nuances and regional preferences. To achieve customer-centric growth, businesses must offer localized and customized solutions tailored to specific regions and segments. Understanding these dynamics is crucial in creating products and services that resonate with customers.

2 Leveraging digital transformation
Digital tools are vital for reaching wider audiences and enhancing customer experiences. By adopting technologies for marketing, sales and service delivery, businesses can gather valuable data to personalize interactions. This builds stronger relationships and ensures convenience for customers.

3 Building trust and loyalty
Trust is paramount in India's market. Businesses should focus on transparency, quality and reliability to foster loyalty. Satisfied customers not only repeat purchases but also become brand advocates through word-of-mouth, amplifying the business's reputation.

4 Innovation in offerings
Innovation extends beyond technology to include product design and service delivery. Companies should continuously adapt by diversifying product lines, offering customization, or exploring new models like subscriptions or e-commerce. Meeting evolving customer needs ensures sustained relevance.

5 Access to finance and resources
Investing in customer-centric initiatives often requires capital. While access to finance remains a challenge for many MSMEs, government schemes and financial incentives can provide support. Utilizing these resources enables businesses to adopt new technologies and improve operations.

6 Regulatory compliance
Adhering to regulations–taxation, labor laws, environmental standards is critical. Compliance avoids legal issues and enhances credibility, reinforcing trust among customers.

7 Collaboration and partnerships
Partnerships with larger corporations or international entities open doors to new markets, technologies and expertise. Such collaborations empower MSMEs to enhance their offerings and deliver superior value to customers.

Cross reads from early adopters across sectors

E-commerce and retail

Amazon:
Renowned for its customer obsession, Amazon has consistently leveraged customer feedback to innovate and improve. From its early days, the company has focused on creating a seamless shopping experience, evidenced by features like one-click ordering and personalized recommendations, which were directly influenced by understanding and responding to customer behaviors and preferences.

Nykaa:
Nykaa India's leading beauty retailer, disrupted the market by understanding the needs of a tech-savvy, brand-conscious audience. Their customer-centric approach includes:

- Digital-first focus: Nykaa created a user-friendly e-commerce platform with personalized recommendations and virtual try-on tools.

- Content and education: They offer informative content like tutorials and reviews, empowering customers to make informed decisions.

- Omni-channel strategy: Nykaa operates physical stores alongside their online platform, offering a seamless customer experience.

- Localization: They cater to diverse regional preferences by stocking a wide range of Indian and international brands.

Bigbasket.com:
BigBasket revolutionized grocery shopping in India by offering convenience and choice to busy consumers. Their customer-centric strategy includes:

- Solving pain points: They tackled the challenges of limited selection and unreliable delivery in traditional grocery shopping.

- Extensive product range: BigBasket offers a wide variety of fresh produce, groceries and household items, all in one place.

- Delivery convenience: They offer flexible delivery slots and ensure timely and efficient delivery across cities.

- Focus on freshness: BigBasket prioritizes sourcing and delivery of fresh produce, building trust with customers.

Flipkart:
Flipkart, the e-commerce giant of India, understood the need for a platform that catered to a price-sensitive and digitally evolving consumer base. Their customer-centric approach includes:

- Value for money: Flipkart offers competitive pricing and frequent sales, attracting price-conscious shoppers.

- Cash on delivery: They implemented cash on delivery (COD) as a payment option, fostering trust and convenience for customers with limited access to online payment methods.

- Local language support: Flipkart offers an interface and customer support in multiple Indian languages, making the platform accessible to a wider audience.

- Delivery network: They invested in building a robust nationwide delivery network, ensuring efficient and timely delivery of products.

Technology and consumer electronics

Apple:
Apple's approach to product development, prioritizing intuitive design and user experience, underscores its customer-centric ethos. The company's continual innovations, driven by keen attention to customer feedback and market trends, have solidified its reputation for products that customers love and remain loyal to.

Financial services and payments

Paytm:
Paytm pioneered digital payments in India, focusing on financial inclusion and ease of use. Their customer-centric approach includes:

- Simple and secure platform: Paytm developed a user-friendly mobile app with local language support to overcome language barriers.

- Widespread acceptance: They partnered with various businesses to ensure wide acceptance of Paytm as a payment method.

- Focus on rural markets: Paytm recognized the potential in rural India and developed solutions for users with limited internet access.

- Financial services integration: They offer a range of financial services like bill payments and money transfers, making the app a one-stop solution.
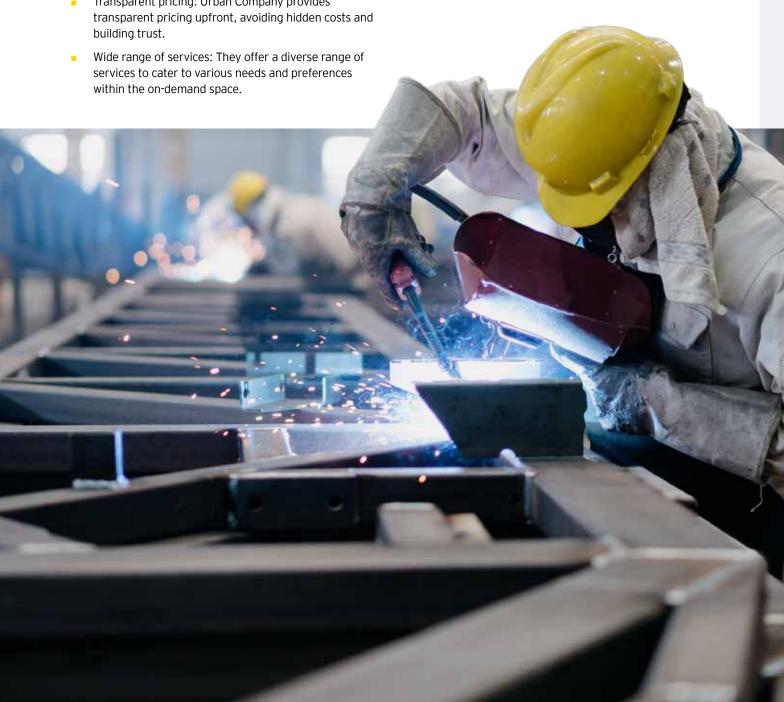
Services industry

Zappos:

This online shoe and clothing retailer is a paragon of customer-centric transformation, making customer service its number one priority. Zappos empowers its employees to go the extra mile to make customers happy, resulting in legendary service that not only resolves issues but also creates delightful and memorable customer experiences.

Urban Company:

Urban Company offers a variety of on-demand services like beauty treatments, home repairs and fitness classes. Their customer-centric approach includes:

- Quality and reliability: Urban Company ensures a high standard of service by rigorously vetting and training service professionals.

- Convenience and flexibility: Customers can book appointments easily through the app and choose flexible scheduling options.

- Transparent pricing: Urban Company provides transparent pricing upfront, avoiding hidden costs and building trust.

- Wide range of services: They offer a diverse range of services to cater to various needs and preferences within the on-demand space.

Digital manufacturing: Powering industrial innovation with smart technologies

3

Key trends in cost optimization

(1) Automation as a cost enabler

Automation has emerged as one of the most powerful tools for cost optimization across industries. By replacing manual processes with automated systems, businesses can reduce labor costs, minimize human error and increase operational efficiency.

Key applications of automation
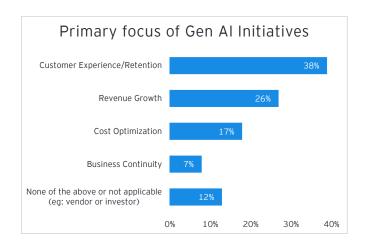
a. Industrial automation

In manufacturing, industrial robots perform tasks such as welding, assembly and packaging. Collaborative robots (cobots) work alongside humans to enhance safety and efficiency. For instance:

- Automotive manufacturers use robotic arms to assemble vehicles with precision and consistency.
- Food processing plants employ automated sorting and packaging systems to ensure hygiene and compliance with quality standards.

b. GenAI

Generative AI (GenAI) is increasingly being adopted across various aspects of manufacturing, transforming how products are designed, produced and optimized. For instance:

- In automotive manufacturing, GenAI can generate lightweight vehicle components that meet safety standards while minimizing material usage.
- Electronics manufacturers leverage GenAI-powered vision systems to identify microscopic flaws in circuit boards, ensuring higher product quality.

Primary focus of Gen AI Initiatives

Customer Experience/Retention	38%
Revenue Growth	26%
Cost Optimization	17%
Business Continuity	7%
None of the above or not applicable (eg: vendor or investor)	12%

0% 10% 20% 30% 40%

c. Lights-out-manufacturing

A revolutionary application of automation allows factories to operate autonomously without human intervention, running 24/7 to maximize productivity while minimizing labor expenses. According to a Gartner study, by 2025, 60% of manufacturers will have more than two completely lights-out processes in at least one of their facilities.[10]

For example,

- Unilever has implemented 'lights-out production' – 24/7 manufacturing with minimal operator intervention. They no longer need operators to carry out routine work has resulted in an almost doubling of labor productivity, freeing up the team's time to spend on more value-adding activities.[11]

② Data-driven manufacturing

Data-driven manufacturing leverages real-time data collection, analytics and connectivity to optimize production processes, reduce waste and lower costs. The integration of sensors, IoT devices and cloud computing enables manufacturers to gain unprecedented visibility into their operations and make informed decisions.

Drivers of data-driven manufacturing

- Industry 4.0 technologies: The convergence of IoT, AI, big data and machine learning has transformed traditional factories into smart factories.

- Real-time monitoring: Sensors embedded in machinery and equipment provide continuous feedback on performance metrics, enabling proactive interventions.

- Process optimization using Digital Twin: Digital Twin allows manufacturers to simulate, analyze and optimize workflows in real-time. By testing scenarios and identifying inefficiencies in the virtual environment, companies can fine-tune production processes, reduce waste and enhance overall efficiency.

Key applications of data-driven manufacturing

a.   Condition monitoring

Sensors track parameters such as temperature, vibration and pressure to detect anomalies early. For example:

- A steel plant uses condition monitoring to prevent overheating in furnaces, avoiding costly repairs and downtime.

- A pharmaceutical company monitors humidity levels during production to ensure product quality.

b.   AI-powered quality control

AI-powered vision systems inspect products for defects at high speeds, ensuring consistent quality. For instance:

- Electronics manufacturers use computer vision to detect microscopic flaws in circuit boards.

- Textile mills employ image recognition to identify fabric imperfections.

c.   Energy management

To enhance energy management, manufacturers use sensors embedded in machinery to track key parameters such as energy consumption, temperature, and vibration. By monitoring energy usage patterns, manufacturers can identify inefficiencies and optimize energy-intensive processes. For instance, Tata Steel has implemented advanced energy monitoring systems across its plants to track energy usage in real time.

[10]Lights-Out Production Will Be a Reality by 2025
[11]Two Unilever sites named most digitally advanced factories | Unilever

③ Predictive maintenance for downtime reduction

Unplanned downtime is a major contributor to operational costs in manufacturing and other asset-intensive industries. Predictive maintenance uses data analytics and machine learning to anticipate equipment failures before they occur, enabling timely interventions that minimize disruptions and repair expenses.

Key applications of predictive maintenance

a. Rotating equipmen

Motors, pumps and compressors benefit greatly from predictive maintenance. For example:

■ An oil refinery uses vibration analysis to monitor pump bearings, preventing catastrophic failures.

■ A wind farm employs acoustic sensors to detect blade imbalances, optimizing turbine performance.

b. HVAC systems

Commercial buildings use predictive maintenance to optimize heating, ventilation and air conditioning systems. For instance:

■ Temperature sensors detect cooling inefficiencies, prompting filter replacements or refrigerant top-ups.

■ Vibration sensors flag motor wear in fans, enabling pre-emptive replacements.

c. Fleet management

Logistics companies apply predictive maintenance to vehicle fleets. For example:

■ Telematics systems monitor engine diagnostics, tire pressure and fuel consumption to schedule servicing.

■ Predictive algorithms alert drivers to potential brake issues, averting accidents.

④ Enhancing yield with Digital Twins

Digital twins are virtual replicas of physical assets, processes or systems. They simulate real-world conditions to test scenarios, optimize performance, and identify opportunities for improvement. In manufacturing, Digital Twins are particularly valuable for enhancing yield—the percentage of usable output relative to input materials. According to Gartner, 13% of organizations implementing IoT projects already use Digital Twins, while 62% are either in the process of establishing Digital Twin use or plan to do so.[12]

Key applications of Digital Twins

a. What-if analysis

■ Digital Twins allow manufacturers to run simulations to understand the impact of different variables on production outcomes. For example:

■ A semiconductor factory simulates wafer fabrication processes to fine-tune recipes and improves chip yields.

■ A beverage company tests bottle filling rates to eliminate spillage and underfilling.

b. Process optimization

■ Manufacturers use Digital Twins to model entire production lines and test changes virtually. For example:

■ A cement plant uses a Digital Twin to optimize kiln temperatures, reducing clinker formation and improving cement quality.

■ A chemical plant adjusts reaction parameters in its twin to increase product purity and yield.

[12]Gartner: digital twins beginning to enter the mainstream
[13](6) Gartner predicts IoT market to grow to $991 billion by 2028 | LinkedIn
[14]First collaborative robots in India - Bajaj auto
[15]Digital Twin Technology in System Design - GeeksforGeeks
[16]Honeywell OT Cybersecurity Solutions: Helps Protect What Matters

Trends supporting digitalization in manufacturing

Digitization has become a cornerstone of modern business transformation, reshaping industries across the globe. Especially, the manufacturing sector is leveraging digital technologies to enhance efficiency, improve customer experiences and drive innovation.

Manufacturing: Industry 4.0 and smart factories

- Manufacturing is at the forefront of the fourth industrial revolution (Industry 4.0), characterized by the integration of IoT, AI, robotics and big data analytics. These technologies are driving operational efficiencies, reducing downtime, and enabling mass customization.

Key trends supporting digitalization in manufacturing

A. Internet of Things (IoT) and Connected Devices

IoT-enabled sensors embedded in machinery collect real-time data on performance metrics such as temperature, vibration and energy consumption. Gartner predicts the IoT market will nearly double, soaring from US$546 billion in 2022 to US$991 billion by 2028[13]. This data is analyzed to optimize production processes and predict maintenance needs. For example, Siemens uses IoT to monitor equipment health in its factories, achieving up to 30% reductions in unplanned downtime.

B. Industrial data lake

As manufacturing becomes increasingly data-driven, the ability to collect, store and analyze vast amounts of information is critical. For instance, an automotive manufacturer uses an industrial data lake to aggregate data from assembly lines, robotic systems and supplier networks. By applying AI algorithms to this data, the company can identify inefficiencies in production workflows, and reduce downtime.

C. Artificial Intelligence (AI) and Machine Learning (ML)

AI and ML are used for predictive maintenance, quality control and process optimization by analyzing vast datasets. For instance, General Electric (GE) uses AI-powered predictive maintenance to monitor jet engine performance. This has reduced unplanned downtime and extended the lifespan of critical components.

D. Robotics

Robotics, particularly collaborative robots (cobots) and autonomous systems, are becoming integral to modern manufacturing. These technologies handle repetitive, dangerous, or highly precise tasks, freeing human workers for more strategic roles. For example, Universal Robots have implemented collaborative robots at Bajaj Auto Ltd and have enabled Bajaj to improve its production capabilities and evolve its multi-model offerings.[14]

E. Additive manufacturing (3D Printing)

Additive manufacturing allows manufacturers to produce complex parts quickly and cost-effectively. It also supports sustainable practices by minimizing material waste. Aerospace companies like Boeing use 3D printing to create lightweight components for aircraft, improving fuel efficiency, shorter lead times, greater design flexibility and reduced inventory costs.

F. Digital Twins

Digital Twins simulate entire production lines or individual machines, enabling manufacturers to test changes virtually before implementing them in the physical environment. For example, Tesla uses Digital Twins to model its production lines and vehicle designs. This allows the company to test new configurations virtually, reducing development time and improving product quality.[15]

G. Cybersecurity for manufacturing systems

As manufacturing becomes more connected, robust cybersecurity measures are essential to protect sensitive data and prevent disruptions. For example, Honeywell developed advanced cybersecurity solutions to safeguard industrial control systems, ensuring uninterrupted operations for its clients in critical sectors like oil and gas.[16]

H. Sustainability and green manufacturing

Digitization supports sustainability by optimizing resource usage, reducing waste, and promoting eco-friendly practices. For instance, Adidas partnered with Carbon Inc. to use 3D printing technology for its Futurecraft sneakers, reducing material waste and enabling localized production to cut carbon emissions.[17]

I. Augmented reality (AR) and virtual reality (VR)

AR and VR are transforming training, remote assistance, and design visualization in manufacturing. For example, Volkswagen uses AR glasses to guide technicians during complex repairs. The glasses overlay step-by-step instructions onto machinery, reducing errors and speeding up maintenance tasks.[18]

4

Cybersecurity: Building resilience and ensuring privacy

In today's digital environment, cyber disasters are not just a possibility; they are inevitable. As the global landscape shifts and new technologies emerge and evolve, organizations are becoming more deeply integrated with technologies, like Machine Learning, Artificial Intelligence, Blockchain, quantum computing and the Internet of things (IoT), among others. In this light, the impact of a major cyber-attack on businesses is compounded many times over. However, what characterizes an organization's strength is its ability to plan, prepare and test its capability to continue providing services to customers, recover from breaches and emerge stronger as a result.

Cyber warfare is an ever-present threat with far-reaching consequences for businesses, governments and society. Attacks take various forms, from ransomware crippling critical infrastructure to sophisticated operations designed to destabilize entire organizations. The loss of sensitive data is often just the beginning; threat actors frequently aim to disrupt operations, erode stakeholder confidence and undermine societal trust.

Cybersecurity and cyber resilience

Cybersecurity and cyber resilience are inherently interconnected, with cybersecurity focusing on safeguarding systems and data and detecting threats, while cyber resilience ensures an organization's ability to recover and adapt in the aftermath of an attack. While cybersecurity aims to prevent breaches, cyber resilience ensures business continuity by enabling rapid recovery and minimizing operational disruption. Together, these strategies form a comprehensive approach that not only defends against cyber threats but also ensures organizations can swiftly restore operations and maintain long-term security and continuity.

Market drivers for cyber resilience

CXOs today are re-writing the organizational technology strategy to embed cyber resilience, with an aim to building resilience-by-design, rather than an after-thought. Digital transformation and global changes in the workplace have introduced various digital layers within organizations. Over 20 billion devices of various types from IoT devices, connected vehicles, drones to fitness trackers are connected to the internet, with millions more being connected daily. The attack surface is increasing at an alarming rate and with it, the spiraling number of security flaws and vulnerabilities. The estimated annual economic cost of cyber-crime is reaching over US$1 trillion, with an average of 150+ days being the time to spot a sophisticated cyber-attack.

This leads to increased cyber threats at various levels. Below are some examples:

At the employee level: The increasing number of employees working from home leads to growing cybersecurity concerns as the vastness of the attack surface increases.

- At data or organizational level: This includes protecting data, which is now being accessed from a multitude of different locations or stored across multiple data centers, various public clouds or SaaS applications spread across the world.

- At the supply chain level: Supply chain cyberattacks, including those targeting software providers, pose significant risks to organizations. Attackers exploit vulnerabilities in third-party vendors or software updates to breach systems and disrupt operations. A single compromised link can lead to widespread consequences, emphasizing the need for strong cybersecurity across multiple partners.

- Regulatory changes: Compliance requirements for data are increasing globally with regulations like GDPR, DORA and India's DPDP Act, 2023. Penalties for non-compliance can be substantial, with GDPR fines reaching millions of dollars.

Emerging technologies: Emerging technologies are amplifying the need for stronger cyber resilience. AI and ML bring new threats like AI-driven malware and ML-enhanced phishing, with insiders exploiting them to bypass security. The advent of IoT introduces countless attack points, where a single compromised device can spread threats across a network. Quantum computing poses future risks to current encryption methods, while deepfakes facilitate disinformation campaigns, damaging reputations and finances. As these technologies evolve, they highlight the urgent need for robust cyber resilience strategies.

It is crucial that organizations understand these risks, protect their data and avoid penalties, while maintaining customer trust – because once trust is lost, it takes years to regain.

Cyber resilience: A four-pillar approach

The concept of cyber resilience is gaining popularity and is still growing. Organizations must recognize that resilience is more than just responding to a breach; it is about proactive planning and implementing a multi-layered defense strategy enabling cyber response and recovery.

Broadly, cyber resilience can be split into four major components – anticipating, withstanding, responding / recovering and learning/adapting from cyber threats.

- **Anticipate threats:** Adopt a proactive approach by thinking like an attacker rather than a defender. Shift from a reactive stance to a strategic, forward-looking posture by identifying vulnerabilities, predicting attack vectors, and implementing preemptive measures to stay ahead of evolving cyber threats.

- **Withstanding attacks:** Develop ability to endure and sustain operations amid cyber threats. This requires a multi-layered defense strategy, integrating robust security frameworks, redundancy and restoration measures, and well-orchestrated incident response protocols to mitigate operational disruptions and safeguard critical assets.

- **Rapid recovery and continuity:** Minimize operational downtime and financial impact by implementing a structured recovery framework. This includes secure, immutable vaulted backups, automated failover systems, and rigorously tested response and cyber recovery strategies to ensure seamless functionality with minimal disruption.

- **Adapt and evolve:** With the cyber threat landscape constantly changing, organizations must adopt an agile, intelligence-driven security approach. Continuous threat monitoring, real-time analytics, and iterative improvements in protection, detection, and recovery frameworks are crucial to staying resilient against emerging and sophisticated cyber risks.

Having the agility and the strength to withstand an attack and quickly bounce back to regular operations and as far as possible, continuing normal operations during an attack is the essence of cyber resilience.

> " Cyber resilience is more than recovery; it is ensuring your operations continue seamlessly, even amidst a cyberattack "
>
> **Pradeep Eledath**
> Partner,
> Technology Consulting,
> EY India

Key takeaways for cyber resilience

Cyber resilience is a critical component for organizations to effectively manage and recover from cyberattacks while maintaining business continuity. A well-defined and proactive incident response plan enables organizations to quickly detect, contain and mitigate the impact of cyber threats, preventing further damage and disruption. Coupled with this, a comprehensive and effective cyber recovery strategy, underpinned by secure, up-to-date cyber backups and automated restoration processes, ensures rapid resumption of essential services with minimal downtime.

Post-incident analysis plays a vital role in strengthening resilience, providing valuable insights that refine response protocols and recovery procedures for future incidents. Furthermore, organizations must invest in building a resilient workforce, equipped with the knowledge and skills to handle cyber crises effectively through ongoing training, simulations and awareness programs. By integrating these response and recovery strategies into their broader cybersecurity framework, organizations not only protect themselves against evolving cyber threats but also enhance their ability to adapt and thrive in an increasingly complex digital environment, ensuring long-term security and operational resilience.

India's full-fledged privacy Law (DPDPA, 2023): Challenges and the road ahead

Background

The Digital Personal Data Protection Act, 2023, was approved by the President of India on 11 August 2023, and published in the official Gazette, thereby making it an Act. The effective implementation of the Act depended on the publication of the Rules by the MeitY. On 3 January 2025, MeitY released the draft DPDP Rules in the Gazette of India, inviting public consultation until 18 February 2025.

We believe it is essential organizations understand the developments that can enable and transform their business operations and data management practices. The published Rules provide the necessary details and implementation guidelines to make the Act operational in practice. It includes 22 rules and 7 schedules, which encompass various provisions of the Act, including Privacy Notice, Consent Manager, Verifiable Parental Consent, Data Retention Timelines, Data Breach, Security Safeguards, and several other regulatory and compliance requirements.

Key aspects of the Act

Applicability of the Act

- The Act is applicable to processing of digital personal data within the territory of India collected online or collected offline and later digitized.

- Further, applicable to processing outside territory of India, if it involves providing goods or services to the Data Principals within the territory of India.

Key definitions

- Personal data means any data about an individual who is identifiable by or in relation to such data.

- Data fiduciary means any person who, alone or in conjunction with other persons, determines the purpose and means of processing of personal data.

- Significant data fiduciary means any data fiduciary or class of data fiduciaries as may be notified by the central government.

Key implications of the act (examples)

Notice: Shall be clear, itemized, in simple language and should include:

- Purpose of processing

- Manner for accessing rights

- Manner to make a complaint to the Board

- Notice to be provided in English or have an option for any language specified in the Eighth Schedule of the Indian Constitution.

Children's data:

- The data fiduciary shall obtain verifiable parental consent before processing any personal data related to children .

- Behavioral monitoring of children or targeted advertising directed at children is prohibited.

Data principal rights

- Rights to access

- Right to correction and erasure

- Rights of grievance redressal

- Right to nominate

Transfer of personal data outside India:

- The central government to notify such countries or territories outside India to which a Data Fiduciary may not transfer personal data.

- Exemptions are available such as legal right or claim, processing by court and tribunal, etc.

Grounds for processing Personal Data:

- Consent from a Data Principal shall be free, specific and informed, unconditional and unambiguous with a clear affirmative action.

Legitimate uses:

- Data Principal has voluntarily provided her personal data.

- Performance of any law or in the interest of sovereignty integrity of India or security.

- To issue any subsidy, benefit, service, certificate, license or permit.

- Compliance with any legal judgement, decree, order.

- Responding to a medical emergency involving a threat to the life.

- In case of an epidemic, outbreak of disease, or any other threat to public health.

- For safety in case of any disaster, or any breakdown of public order.

- For the purposes of employment or those related to safeguarding the employer from loss or liability.

Penalties of non-compliance (examples):

- Non-compliance of the provisions by Data Fiduciaries is up to INR250 crore.

- Breach in observance of duty of Data Principal is up to INR10,000.

- Breach in not giving notice of personal breach is up to INR200 crore.

- Breach in observance of additional obligation in relation to children is up to INR200 crores.

- Twelve Rules are directly applicable to Data Fiduciaries and mandate their compliance while the remaining seven focus on the establishment and operation of Data Protection Board. Additionally, one is for state, and its instrumentalities and two other provisions.

What do the 22 rules clarify?

- Further clarification on the notice to be provided to Data Principals

- Registration and obligations of Consent Manager

- Reasonable security safeguards: Technical and organizational measures

- Personal data retention timelines as per class of Data Fiduciaries

- Timelines for intimation of Personal Data breach to the Board: 72 hours

- Verifiable consent for processing of personal data of child or of a person with disability who has a lawful guardian

- Exemptions from certain obligations for processing personal data of child

- Additional obligations for Significant Data Fiduciaries (e.g., DPIA, audit)

- **What do the seven schedules clarify?** Four Schedules outline various requirements to guide the Data Fiduciaries in taking appropriate action for achieving compliance, while the remaining three pertain to the operation of the Board. These include:

- Conditions of Registration of Consent Manager with the Board

- Obligations of Consent Manager

- Elaborative Technical and Organizational Measures

- Classification of data fiduciaries for clarifying data retention periods

- Class of data fiduciaries and purposes that are exempted from the conditions of processing children's data

Key nuances of the 2025 Rules

Below are the key nuances of the Rules that every business must understand to ensure compliance and protect personal data of the Data Principals:

- **Notice and consent:** Data Fiduciaries need to assess if their privacy notices and consent banners are in alignment with the DPDP Rules and provide all necessary information to the Data Principals.

- **Verifiable parental consent:** Data Fiduciaries shall ensure a system is in place to obtain verifiable consent of the parents or legal guardian while processing personal data of children or person with disability.

- **Data Principal rights:** Data Fiduciaries must establish clear procedures, communication channels, and systems to handle Data Principals' rights requests and ensure an effective grievance redressal system.

- **Consent Manager:** Data Fiduciaries need to ensure that the Consent Manager being appointed meets the conditions of the Board and follows the obligations set by the Rules.

- **Security safeguards:** The Rules have provided reasonable security safeguards to be implemented by the Data Fiduciaries for the protection of personal data and preventing personal data breaches.

- **Personal Data breach:** Data Fiduciaries need to inform affected Data Principals and the Board without delay and provide a detailed report to the Board within 72 hours, which includes broad facts, circumstances, remedial measures, findings, etc.

- **Data retention timelines:** Data Fiduciaries are now required to ascertain a time on the data erasure of the personal data processed by them depending on the class of Data Fiduciary they fit in as specified by the

Rules(specific implications mentioned for ecommerce, gaming, social media companies).

■ **Processor due diligence:** Data Fiduciaries must exercise greater due diligence when outsourcing tasks to third parties and establish comprehensive data processing agreements with such processors, explicitly outlining the processors' obligations.

■ **Significant Data Fiduciaries:** Significant Data Fiduciaries must conduct Data Protection Impact Assessment, annual audits, ensure algorithmic software protects data rights, and comply with data transfer restrictions outside India.
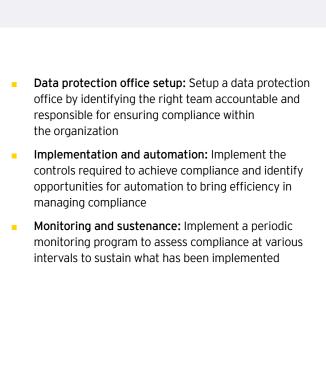
The unknowns:

■ **Significant Data Fiduciaries:** The Rules have not specified the specific of Data Fiduciaries that will be considered as Significant Data Fiduciaries. The Significant Data Fiduciaries will be notified by the central government based on an assessment of relevant factors.

■ **Consent Manager– Internal vs. External:** The rules do not clarify whether the Data Fiduciaries are permitted to appoint an in-house Consent Manager and if allowed, would that need to be registered with the Board, and whether such an appointment would constitute a conflict of interest. Furthermore, rules do not elaborate if and how organizations can continue using existing consent management mechanisms adopted proactively or for compliance with global data protection regulations.

■ **Exemptions for children's data processing:** The Rules outline five categories of Data Fiduciaries and list certain purposes of data processing that are exempt from certain obligations for processing children's data. However, the rules do not specify whether this exemption applies to all other Data Fiduciaries that do not offer child-directed or lucrative* products and services.

■ **Retrospective consent:** The Rules have not provided clarity on what consent obtained prior to commencement of the Act will be acceptable as valid consent i.e., whether implied consent with a fresh notice would suffice, or should it be an explicit valid consent for specific purposes along with a fresh notice.

■ **Timeline for Data Principal Rights and grievance redressal:** The Rules have not prescribed any time-period for Data Fiduciaries to address the rights of Data Principals. Additionally, the Rules have given Data Fiduciaries the option to specify the time for their grievance redressal system.

■ **Requirements for cross-border data transfer:** The Rules have not specified any list of countries with restriction on transfer of personal data along with instruments to be put in place for such cross-border data transfer. Any such requirements shall be specified by the central government by general or special order.

■ **Journalistic exemption:** The Rules do not provide any exemptions for journalists and media organizations in relation to complying with the Act's obligations, particularly in balancing these obligations with the freedom of expression and the right to information in the public interest.

■ **Exemptions for start-ups:** The Rules do not specify the threshold for volume, nature of personal data and class of Data Fiduciaries, including Start-ups who are exempted from specific obligations relating to notice, DPIA, retention timeline and Data Principal Rights as per the Act.

■ **Restriction on special category of Personal Data:** The Rules have not specified the categories of personal data and definition of traffic data on which restriction on cross-border data transfer by Significant Data Fiduciaries shall apply.

■ **Notification of data breach to Data Principals:** The Rules mention that as part of data breach notification to the Data Protection Board within 72 hours, details on notification to data principals shall also be provided. However, there is no clarity if it is mandatory to report every data breach to the data principal and whether such intimation needs to be provided to each data principal before it is reported to the Board.

The journey to compliance: 10 steps every organization must adhere to

■ **Data privacy assessment:** Assess the current data privacy posture, working practices and documentation against the requirement of the DPDP Act and Rules

■ **Data discovery and mapping:** Identify the Personal Data touch points and conduct data discovery and mapping activities

■ **RoPA and data flow diagram:** Document personal data processing activities and its flow across various processes, systems, applications, third parties, etc.

■ **Consent and notice management:** Prepare consents, cookie banners, cookie policies and privacy notices to be implemented across touchpoints, where personal data is collected

■ **Privacy impact assessment:** Identify data privacy risks by performing privacy impact assessments for processing activities and define controls to be implemented for mitigation

■ **Third-party risk management:** For third parties processing personal data, ensure organizational and technical security measures are implemented through inclusion within contracts and strong governance practices

■ **Technical safeguards:** Identify and implement the required technical safeguards to ensure protection of personal data from data breaches

- **Data protection office setup:** Setup a data protection office by identifying the right team accountable and responsible for ensuring compliance within the organization

- **Implementation and automation:** Implement the controls required to achieve compliance and identify opportunities for automation to bring efficiency in managing compliance

- **Monitoring and sustenance:** Implement a periodic monitoring program to assess compliance at various intervals to sustain what has been implemented

5 Generative AI: Data-driven insights for the future

GenAI in India: New vectors of disruption

India's GenAI landscape is rapidly evolving, characterized by unique market dynamics and a burgeoning ecosystem of innovation. Unlike developed markets, India's GenAI trajectory is shaped by its vast and diverse population, a young and tech-savvy workforce, and specific socio-economic challenges. In this chapter, we explore five key vectors driving GenAI disruption in India, highlighting both the tailored adoption of global solutions and the emergence of indigenous products and solutions designed to meet local needs.

01 Chat, voice, regional languages augment digital interfaces

Using mobile apps can be hard work. Screens are small, the navigation even for simple transactions can become complex and it is not easy to personalize the experience. For the less digitally savvy and those more comfortable in regional languages, apps and by extension a large part of the digital economy are largely out of reach.

GenAI is driving a dramatic change in digital interfaces. One can see the emergence of a new UI – led by AI assistants, activated by voice, extended into regional languages and augmented by chat.

This will rapidly begin to augment and in some cases replace the current app-based point and click model. Over time, one can even imagine an LLM dynamically generating the UI based on the context of the transaction.

This is already beginning to happen. More than one-third of Google searches in India are voice-based, a stark contrast to just 5% in developed markets. This growing preference for voice interaction is evident in initiatives like the AskDisha chatbot by CoRover, which supports ticket bookings on the IRCTC app through voice, chat, and point-and-click interfaces. Similarly, the National Payments Corporation of India (NPCI) has pioneered solutions such as Hello! UPI, which enables transactions via simple voice commands. Feature phone users and those in low-connectivity areas can use UPI 123PAY through voice prompts, missed call services, and callback mechanisms, all without an active internet connection.

The new interfaces also have the potential to transform accessibility for underserved sections of India, particularly in semi-urban and rural areas. There is a need for affordable solutions in regional languages, intuitive interfaces and services designed for specific needs. GenAI is emerging as a transformative force, enabling innovations that drive financial inclusion, healthcare access, and educational outreach through localized, cost-effective solutions.

In education, AI-powered platforms will enable personalized tutoring in regional languages, offering adaptive learning experiences tailored to individual progress and needs. In healthcare, GenAI will address resource shortages by enabling remote diagnostics, analyzing longitudinal health data, and delivering personalized care recommendations. These advancements promise to redefine accessibility, empowering communities and creating a more inclusive digital ecosystem across India.

India's consumer landscape, unique characteristics and market dynamics

India 1

Comprises the top 10%-15% of households and approximately 100 million people. This segment is affluent, urban, and digitally savvy, driving a significant portion of the digital economy and consuming premium products and services.

India 2

Encompasses approximately 300 million individuals from smaller cities and semi-urban areas. These consumers have moderate purchasing power, are price-sensitive yet aspirational, and seek value-driven services in education, healthcare and finance.

India 3

The largest segment, with approximately 900 million people, is predominantly rural, lower-income, and less digitally literate, communicating mainly in regional languages and focusing on affordable, essential services.

How business strategies could differ for India 1 and India 3

Industry	Digital model	India 1 strategy	India 3 strategy
Financial services	Fintech	Personalized investment management, AI-driven wealth advisory, predictive analytics for portfolio performance	AI-based micro-lending, regional language support in financial apps, voice-based banking interfaces
	Insurtech	Predictive risk assessment, personalized insurance policies, automated claims processing	Affordable micro-insurance through AI-based risk assessment, simplified AI chatbots for policy inquiries
	Credit scoring	AI-driven credit scoring models using alternative data (social, transaction history)	Credit scoring for the unbanked using local data (e.g., mobile transaction patterns), low-cost loans accessible via mobile
Media	Digital media	Personalized content curation, AI-driven recommendation engines, targeted advertising based on behavior analysis	Regional language content recommendations, AI for local news curation, audio/voice-based access to content
	Entertainment	AI-generated media content (e.g., news articles, video recommendations), immersive AR/VR experiences	Regionalized AI-driven video recommendations, low-data streaming options, automated dubbing or subtitles
Healthcare	Healthtech	AI-driven diagnostics, predictive health analytics, telemedicine with AI-driven triage	AI-based mobile health diagnostics, offline AI health consultations, regional language support for healthcare apps
	Telemedicine	AI-driven virtual consultations with specialists, medical imaging analysis	Mobile-based telemedicine with basic AI for symptom checks, local language support for rural health workers
	Pharmaceuticals	AI-led drug discovery, personalized medicine, genetic analysis for tailored treatments	Low-cost AI solutions for public health issues, predictive analytics for vaccine distribution in rural areas
Retail and E-commerce	E-commerce	AI-driven personalized shopping experiences, dynamic pricing, targeted product recommendations	AI-driven local language shopping apps, voice shopping, inventory optimization for local vendors
	Supply chain	AI-based demand forecasting, real-time supply chain tracking, and logistics optimization	Simplified AI tools for small retailers, inventory management for local shop owners, predictive demand analytics
	Payments	AI-powered fraud detection, seamless digital payments, biometric payments	AI-based digital payments using local authentication methods, voice-activated transactions in local languages
Education	Edtech	Personalized learning paths, AI-driven tutoring, content recommendations based on learning patterns	Localized, AI-driven learning content in regional languages, basic mobile AI tutoring, voice-activated education platforms
	Assessments	AI-based proctoring, adaptive testing, automated grading	Low-cost, AI-based grading systems for large groups, offline AI tools for grading and assessments
	Skill training	AI-driven upskilling and reskilling programs with personalized learning tracks	AI-powered skill training for local workforce in regional language, mobile-based skill assessments and recommendations

02 Agents enable the transformation of knowledge work

The advent of AI Agents – autonomous LLM-powered software capable of understanding context, accessing a toolkit of resources skillfully, making decisions, and executing actions iteratively towards achievement of a goal – and agentic orchestration promises to further enhance advancements. The technical aspects of agents is discussed in detail in the previous section.

India's significant role in the global knowledge economy is evident through its extensive workforce in sectors like information technology, finance and customer service. The rapid integration of AI Agents into these fields is reshaping traditional ways of working, presenting both opportunities and challenges for Indian professionals. Most notably, Indian knowledge workers have leaned in, with 92% of them utilizing AI in their workplaces, meaningfully surpassing the global average of 75%, according to the 2024 Work Trend Index by Microsoft and LinkedIn.

In **software development**, AI-powered code editors such as Cursor can comprehend code context, suggest bug fixes, and implement related changes across entire files. Features like inline chat enable developers to direct the AI for modifications ranging from minor edits to extensive codebase overhauls. This evolution allows programmers to focus more on system architecture and logic, as AI manages repetitive tasks.

The **legal sector** is experiencing a transformation through AI in contract drafting and document review. Agentic tools like Type integrate with legal databases and precedent libraries, expediting the drafting process. These AI solutions enhance accuracy by suggesting pertinent clauses and ensuring compliance with regulatory standards.

Financial analysts benefit from AI systems that automate report generation, document processing, compliance monitoring, and anomaly detection. AI streamlines processes such as invoice management by extracting and integrating data into ERP systems, reducing manual errors.

Content creators leverage GenAI tools capable of producing drafts, performing grammar and style checks, and offering SEO optimization suggestions. These platforms enable writers and editors to focus on creative ideation and storytelling. AI-powered systems analyze extensive data to generate personalized content, enhancing engagement and relevance.

In **customer support,** AI-driven chatbots and virtual assistants efficiently handle routine inquiries, providing 24/7 support and prompt resolutions. AI tools today promise to manage a spectrum of customer interactions, from account balances and transaction histories to more complex financial advice, thereby enhancing customer satisfaction and operational efficiency.

By automating routine tasks, AI Agents will enable professionals to focus on strategic, creative, and complex aspects of their work, thereby enhancing productivity and fostering innovation. For India, with its extensive knowledge workforce, embracing AI Agents and agentic architectures is crucial to maintaining competitiveness and harnessing the full potential of its human capital. The impact of AI on human effort reduction and elimination extends beyond knowledge work, as detailed in the chapter 'Transforming work with GenAI'.

03 LLMs are not all you need: Toward compound AI systems

It is becoming increasingly clear that LLMs have significant limitations. They are expensive to use, hallucinate and often miss out on key context that is critical for enterprises as they seek to build intelligent systems.

Enterprises will increasingly rely on hybrid architectures, where multiple AI models – ranging from small, task-specific models on edge devices to large foundational models in the cloud – are orchestrated to work together. These models will operate at different levels of the enterprise stack, balancing cost, latency, and performance needs. For example, lightweight models might handle quick, edge-based tasks, while more complex models, fine-tuned to enterprise data, will reside in cloud environments.

In February 2024, the Berkeley AI Research (BAIR) Lab introduced the concept of compound AI systems, which integrate LLMs with traditional

How GenAI models amplify overall system capabilities

Construction project management	Recommendation engines in online commerce	Financial services	Education	Industry 4.0 + GenAI
Advanced project management software now incorporates drone footage to assess construction sites. GenAI processes this visual data, providing insights that integrate with traditional AI models to enhance project oversight and decision-making.	In e-commerce, images – such as those of a living room – are analyzed using multi-modal vision models. The interpretations inform classical ML-based recommendation engines, suggesting optimal décor options from catalogs. This integration improves the relevance and personalization of recommendations.	Loan applicants interact with GenAI-powered chatbots to provide detailed information and answer follow-up questions. The collected data is processed by traditional ML models, refining credit decision-making processes and improving accuracy in risk assessment. The ensemble significantly reduces time to decision.	Adaptive testing has evolved with GenAI, extending beyond multiple-choice to include long-form subjective answers. This advancement allows for more comprehensive assessments, tailoring question difficulty based on previous responses and providing a deeper understanding of student capabilities.	GenAI combines traditional ML models with diverse inputs like workers' logs and product manuals. This fusion enhances predictive maintenance strategies, leading to more informed decisions on the factory floor and reducing downtime.

AI/ML techniques, classical programming, and external tools like internet search APIs. This approach marks a big shift from relying solely on monolithic models to employing multifaceted systems that leverage the strengths of various components.

GenAI exemplifies this paradigm by enhancing existing systems across diverse industries. Rather than serving as standalone solutions, GenAI models are increasingly embedded within traditional AI and ML processes, creating synergistic effects that amplify overall system capabilities.

Compound AI systems are already prevalent today. A leading Indian pharmaceutical company relies on its field sales force to engage doctors and share product updates. Leveraging their extensive datasets such as visit logs, doctor feedback, prescription patterns, and local disease insights, which is a mix of quantitative and qualitative data. The revamped sales app now leverages

all of these through traditional AI and GenAI to deliver personalized recommendations for each doctor, including tailored product suggestions, comparisons to regional peers, and relevant disease trends.

The evolution of Compound AI systems signifies a transformative approach in AI, where the integration of GenAI with traditional methods leads to more robust, efficient, and intelligent applications across various sectors. As this trend continues, we anticipate the development of innovative products that harness the combined strengths of these technologies, driving significant advancements in their respective fields.

04 The falling cost of AI

The cost of implementing AI solutions has plummeted, making them increasingly accessible to enterprises. OpenAI's GPT API costs, for example, have dropped nearly 80% in two years, while open-source releases like Meta's Llama are unlocking new capabilities. India-specific fine-tuned versions of these models enable affordable customization. Although GPU supply remains tight, alternatives are emerging, allowing AI inference to run without high-end GPUs.

Open-source models such as Meta's Llama series, Mistral, Google's Gemini, Microsoft's Phi, and Alibaba's Qwen are providing powerful tools at a fraction of the cost of proprietary models. Innovations like prompt caching and batch processing further enhance affordability for LLM utilization.

Cloud providers are also driving cost reductions with pricing based on Tensor Processing Units (TPUs), delivering faster and cheaper AI solutions. Improved GPU access has enabled organizations to fine-tune and deploy open-source models, reducing reliance on heavy infrastructure. Hybrid strategies, combining on-premise solutions for sensitive data with cloud-based APIs for scalability, are proving to be cost-effective to expand AI deployments.

Technological advancements like quantization, which optimizes AI models for CPU efficiency, are further reducing hardware costs. Combined with affordable cloud services, these innovations are empowering businesses to scale AI initiatives and push the boundaries of innovation, driving unprecedented growth in AI applications.

India's traditionally low labor costs have led some to question the cost versus quality trade-off in deploying LLMs to augment human effort in the Indian market. However, the rapidly decreasing costs associated with AI deployment are reshaping this perspective.
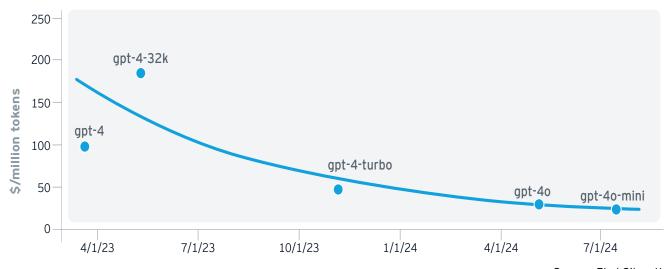
In August 2024, founder of DeepLearning AI and educator Andrew Ng noted, "Let's say you build an application to assist a human worker, and it uses 100 tokens per second continuously: At $4 per million tokens, you'd be spending only $1.44 (~INR120) per hour – which is significantly lower than the minimum wage in the U.S. and many other countries." With Sarvam AI's offer of INR1 per minute, this cost drops further to half as much (INR60 per hour), making LLM-led offerings extremely price competitive in the Indian context.

The convergence of declining AI deployment costs and a deep pool of tech talent capable of building AI applications presents a compelling opportunity for widespread AI adoption. As AI becomes more affordable, even for small and medium-sized enterprises, it has the potential to drive innovation, enhance productivity, and contribute to economic growth across various sectors.

Token cost of GPT-4 level models over time

Cost for 2 million tokens (input + output) decreased from US$180 to US$0.75 in two years, becoming 240x cheaper

Source: Elad Gil on X

05 The evolution of an Indic AI ecosystem

A lot has been said about India being the use case and data capital of the world. With more than 700 million connected consumers and the lowest data rates in the world, India will play home to many sunrise industries that will seek to infuse AI at scale across their business models. There is also now a significant focus on integrating AI into India Stack to buttress its already strong digital public infrastructure. Will India see an Indic AI stack with tools that compete with global offerings and is relevant in an enterprise context?

The race to build Indic LLMs and agents

One significant area of focus has been the linguistic diversity of India – there has been a mushrooming of Indic LLMs that leverage open-source models fine-tuned with Indian language datasets. A key initiative in this space is Bhashini, a government-led AI project aimed at creating an open-source Indic language dataset to expand internet and digital service accessibility in Indian languages. By facilitating content creation in languages like Hindi, Tamil and Bengali, Bhashini is democratizing the benefits of AI for India's multilingual population.

The global AI community has also expressed keen interest in Indic languages. For example, Abu Dhabi-based G42 introduced Nanda, a Hindi LLM trained on 2.13 trillion tokens, aiming to empower over half a billion Hindi speakers with GenAI capabilities. Similarly, BharatGen, the first government-funded multimodal LLM initiative, focuses on creating efficient and inclusive AI tailored to Indian needs. Tech Mahindra's Project Indus further advances the development of Indic foundational models, beginning with Hindi and its over 37 dialects, bridging linguistic gaps for enterprises. TWO.ai, another notable player, has introduced SUTRA, a multilingual AI engine supporting over 50 languages, including Hindi and Gujarati. SUTRA is designed to power immersive AI experiences that extend beyond text and voice, addressing India's linguistic diversity effectively.

AI4Bharat, a research lab at IIT Madras, has been instrumental in advancing Indian language technology. Their contributions include extensive open-source datasets like IndicCorp v2 and tools that underpin the growing Indic LLM ecosystem. Despite these advancements, challenges persist. The lack of robust datasets across India's diverse languages affects the training and performance of these models. Data often requires significant cleaning and processing to ensure usability, while concerns about responsible data use, privacy, and ethics remain pressing. Initiatives such as Project Vaani, a collaboration between IISc and Google

to collect Indic speech datasets, are critical in addressing these gaps.

The development of AI Agents tailored to Indian contexts represents another promising area. These agents not only address linguistic diversity but are fine-tuned with domain-specific datasets, enhancing their utility in sectors like BFSI, healthcare, and legal technology. Sarvam AI leads the way with its GenAI platform featuring Sarvam Agents – voice-enabled, multilingual solutions designed for Indian enterprises. Their open-source models, such as Shuka 1.0 (an open-source AudioLM), and APIs supporting 10 Indic languages, mark significant milestones. Sarvam AI's cost-effective pricing model of INR1 per minute for AI-driven customer interactions ensures accessibility for businesses of all sizes. Similarly, Kogo.ai has developed a platform enabling companies to build AI agents that can converse in Indic languages. Starting with Hindi, Urdu and English, Kogo.ai plans to expand its offerings to additional languages, providing versatile solutions for enterprises seeking multilingual AI capabilities.

Benchmarks play a crucial role in measuring advancements in LLMs and Indic LLMs are no different. IndicGenBench, introduced in 2024, is a comprehensive benchmark designed to assess the performance of LLMs across 29 Indic languages. It includes tasks like cross-lingual summarization, machine translation, and question answering, providing multi-way parallel evaluation data for under-represented Indic languages. Such benchmarks are essential for driving innovation and ensuring the models meet the diverse needs of India's population.

These developments collectively represent a growing ecosystem of Indic LLMs and agents designed to cater to India's linguistic and cultural diversity. From addressing challenges in data quality to building sophisticated AI Agents and creating robust benchmarks, the Indic AI landscape exemplifies the transformative potential of AI to make technology more inclusive and impactful for a multilingual society.

A burgeoning GenAI start-up ecosystem

India's burgeoning GenAI start-up ecosystem has also contributed to this momentum. The number of GenAI start-ups in India surged 3.6 times from over 66 in the first half of 2023 to more than 240 by mid-2024, according to Nasscom's "India's Generative AI Start-up Landscape 2024" report. These start-ups have cumulatively attracted over US$750 million in funding, with 75% generating revenue in the first half of 2024 compared to just 22% in the same period the previous year. The ecosystem now includes 17 native GenAI language models and a significant increase in start-ups offering GenAI assistants, placing India sixth globally in GenAI start-up ecosystems among major economies.

Towards a sovereign AI cloud

In parallel, the development of digital infrastructure in India has gained momentum. Leading corporations such as Reliance, Tata Group, Tech Mahindra, and Wipro have partnered with Nvidia to procure advanced GPU infrastructure. Mid-sized players like Yotta Data Services, E2E Networks, and Sify are also providing cloud GPU resources to enable the hosting of LLMs. Moreover, the Ministry of Electronics and Information Technology (MeitY) is actively working to empanel partners capable of delivering up to 10,000 GPUs, thus empowering start-ups, researchers, and academicians to contribute to AI innovation.

The development of an Indic AI ecosystem reflects the potential for India to leverage its unique linguistic and cultural diversity in shaping AI innovations. Initiatives like Bhashini, BharatGen, and the commitment to purchase 10,000 GPUs, along with the rise of GenAI start-ups, demonstrate significant early progress. However, addressing challenges such as data quality, infrastructure gaps, and ethical considerations will be critical for sustained growth.

Despite the hurdles, the strides made so far underscore a strong foundation for further development. Collaborative efforts among government, industry, and academia are setting the stage for a comprehensive AI ecosystem tailored to India's needs. While there is still much work ahead, the momentum and focus evident today are encouraging indicators that India is well-positioned to create an AI ecosystem that is inclusive, impactful, and globally relevant.

Large funding deals in the GenAI in India

Target Company	Target company sector	Bidder company	Deal value (US$ million)
Krutrim SI Designs	Technology	Matrix Partners	50
AiDash	Industrial, Energy and utility	Lightrock	50
Decision Point Pvt Ltd (70% stake)	CPG	Latent View Analytics	39.1
Neysa Networks Pvt Ltd	Technology	NTT Venture Capital, Z47, and Nexus Venture Partners	30
Nanonets	Technology	Accel Partners, Elevation Capital, Y Combinator	29
Nurix AI	Technology	Accel Partners, General Catalyst Partners	27.5
Ema	Healthcare	Accel, Section 32, and Prosus Ventures	25
Neysa Networks Pvt Ltd	Software	Matrix Partners India Investment Holdings LLC	20
Aereo (Formerly Aarav Unmanned Systems Pvt Ltd)	Industrials	360 One Asset Management Ltd, StartupXseed Ventures LLP, Navam Capital	15
Niqo Robotics	Agriculture	Bidra Innovation	13
Cloudphysician	Healthcare	Peak XV Partners	10.5
Vahan Technologies India Pvt Ltd	Technology	Khosla Ventures LLC, Y Combinator Inc, Gaingels LLC, Vijay Shekhar Sharma (Private Individual)	10

List is not exhaustive

Digital technology infusion in the manufacturing sector: A focus on MSMEs and start-ups

6

The Indian manufacturing sector is undergoing a significant transformation with the adoption of digital technologies. Industry 4.0–comprising Artificial Intelligence (AI), the Internet of Things (IoT), Robotics, Cloud Computing, and Big Data Analytics–is revolutionizing traditional manufacturing processes, improving efficiency, reducing costs, and enhancing product quality. The next phase, referred to as Industry 5.0, focuses on embedding sustainable technology in manufacturing processes and enhancing human-machine interaction. This evolution is already on the drawing boards of leading technology research and development organizations.

Manufacturing in India contributes around 15% of GDP, a figure that has been on a downward trend in recent years. This is significantly lower compared to Germany (20%) and China (29%), highlighting a substantial opportunity for growth. Under the Atma Nirbhar Bharat mission, the Government of India has set an ambitious target for increasing the manufacturing sector's contribution to 25% of GDP. Achieving this goal in today's interconnected world requires a strong infusion of emerging technologies.

This digital transformation is particularly crucial for Micro, Small, and Medium Enterprises (MSMEs), which, according to the Ministry of MSME, Government of India, constitute about 30% of the country's GDP, 40% of manufacturing output, and 45% of exports. However, despite their pivotal role, MSMEs often face challenges in adopting digital technologies. Government initiatives aimed at fostering innovation have emerged as key enablers in accelerating this transition.
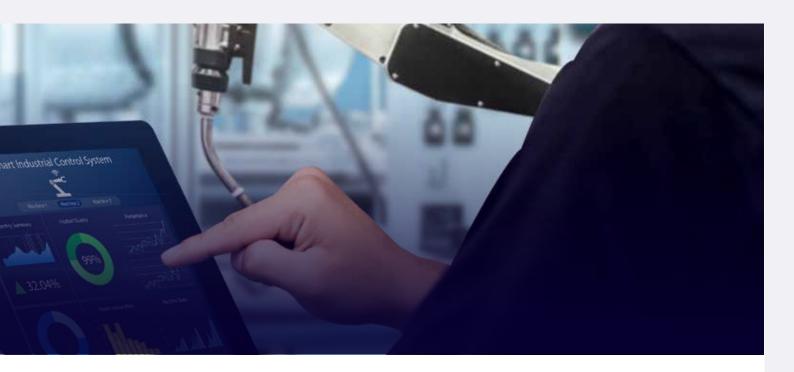
Prominent digital technologies impacting MSME manufacturing

1. IoT for smart manufacturing

IoT is enabling MSMEs to transition to smart manufacturing, where connected devices and sensors provide real-time insights into machine performance, predictive maintenance, and inventory management. According to a NASSCOM report, IoT adoption in Indian manufacturing is projected to reach US$15 billion by 2025. Frugal innovation by Indian start-ups is helping small manufacturers implement IoT-based condition monitoring systems, reducing downtime and improving efficiency.

2. AI for predictive analytics and automation

AI is transforming manufacturing by enabling predictive analytics, automated quality control, and supply chain optimization. As per an EY analysis, AI-driven predictive maintenance can reduce machinery downtime by 20% to 30% and cut maintenance costs by 10% to 15%. Indian start-ups are leveraging AI for industrial automation, helping MSMEs streamline operations and enhance product quality.

3. Cloud computing for cost-effective digitization

Cloud computing enables MSMEs to digitize operations without investing heavily in IT infrastructure. The Indian cloud computing market is expected to grow at a CAGR of 20% between 2023 and 2028. Many Indian companies now offer cloud-based ERP solutions, allowing MSMEs to manage inventory, financial transactions, and customer relationships seamlessly.

4. 3D printing for rapid prototyping and cost reduction

Additive manufacturing (3D printing) is revolutionizing product development by enabling rapid prototyping and reducing material wastage. The Indian 3D printing market is projected to grow at 20% CAGR by 2028, driven by sectors such as automotive, healthcare, and aerospace. The declining costs of 3D printing technology and raw materials are making it more accessible to MSMEs, allowing them to manufacture prototypes and customized products at a fraction of traditional costs.

5. Robotics and automation for productivity enhancement

The adoption of robotics in manufacturing is increasing rapidly, with robot deployment in India growing by 54% in 2021 (as per the International Federation of Robotics). Robotics help MSMEs reduce manual errors, improve precision, and increase production speed.

The role of start-ups in driving innovation

Start-ups play a critical role in democratizing access to digital technologies for MSMEs by leveraging open-source technologies and digital public infrastructure (DPI). Some ways in which start-ups enable MSMEs include:

- Providing low-cost digital solutions: Start-ups offer affordable IoT, AI, and cloud computing tools, making digital adoption financially feasible.

- Enhancing supply chain efficiency: Logistics start-ups use AI and data analytics to optimize supply chains, reducing costs for small manufacturers.

- Developing smart manufacturing platforms: Start-ups provide IoT-enabled platforms that help MSMEs digitize production and monitor real-time performance.

- Facilitating access to financing: Fintech start-ups are improving access to capital for MSMEs, especially for working capital and micro-loans.

Government interventions to enable digital transformation

To support MSMEs in adopting digital technologies, the Government of India has launched several initiatives that focus on digital infrastructure, financial assistance, and capacity building on emerging technologies. Some of such initiatives are mentioned below.

The Ministry of MSME, Government of India, runs schemes like Digital MSME Scheme, which aims to promote cloud computing, AI, and IoT adoption among MSMEs and provides subsidies on adoption of cloud-based software services. Similarly, MSME Competitive Lean Scheme (MCLS) helps MSMEs implement Lean Manufacturing, Automation, and Robotics. Financial Assistance and Credit Support for

capital investment is also provided through Credit Guarantee Fund Trust for Micro and Small Enterprises (CGTMSE) in the form of collateral-free loans for MSMEs. In addition, the Ministry of Heavy Industries and Public Enterprises, Government of India, has launched SAMARTH Udyog Bharat 4.0, with an aim to promote Industry 4.0 adoption through Smart Manufacturing Demonstration Centres (SMDCs). So far, five such centers have been established.

Challenges and suggested solutions

Despite the immense potential, MSMEs face several challenges in adopting digital technologies. These include:

High implementation costs: Many small enterprises lack the capital to invest in advanced technologies such as AI and robotics. The government can expand subsidies and incentives for technology adoption, thereby reduce the cost of capital. Promoting shared infrastructure using pay-per-use models can also reduce costs.

1. Lack of a skilled workforce: Over 60% of MSMEs lack employees trained in digital tools, limiting their ability to implement new technologies. Government-funded digital skilling programs should be expanded in collaboration with industry leaders. Start-ups can develop low-code/no-code platforms to reduce the skill barrier for technology adoption.

2. Cybersecurity concerns: Increased digitalization exposes MSMEs to cyber threats, necessitating robust security measures. MSMEs should be provided with cybersecurity awareness programs and easy-to-implement security tools. Government schemes can offer additional financial assistance for adopting cybersecurity measures.

3. Limited Awareness and decision-making challenges: Many MSMEs are unaware of the right digital technologies for their needs and struggle with decision-making. Industry associations and government bodies can conduct regular outreach and awareness campaigns. AI-driven recommendation platforms can guide MSMEs on technology adoption based on business needs.

Shaping the future: Digital transformation in India's manufacturing sphere

The infusion of digital technology is reshaping India's manufacturing sector, with MSMEs at the heart of this transformation. The integration of IoT, AI, cloud computing, robotics, and 3D printing is helping small manufacturers enhance efficiency, improve product quality, and compete in global markets.

Start-ups are playing a vital role in making digital solutions accessible and affordable for MSMEs, while government interventions, along with initiatives like Make in India, are driving large-scale adoption.

As India aspires to become a $5 trillion economy, the modernization of its manufacturing sector will be key. By fostering innovation, strengthening policy support, and addressing adoption challenges, MSMEs can emerge as global leaders in smart manufacturing, propelling India towards becoming a world-class industrial hub.

7 The path forward

Key takeaways for industry leaders

In today's rapidly evolving digital landscape, industry leaders must recognize that digital transformation is not just a technological shift but a strategic imperative. To remain competitive and future-ready, here are the critical takeaways every leader should internalize:

1. Customer-centricity is the North Star

Customers are at the heart of every successful business strategy. In the digital age, their expectations have shifted toward seamless, personalized, and convenient experiences. Leaders must prioritize:

- Leveraging data analytics and AI to understand customer behavior and preferences
- Adopting omnichannel strategies to engage customers across touchpoints
- Building trust through transparency, security, and exceptional service
- Businesses that fail to meet these expectations risk losing market share to more agile competitors

2. Data is the foundation of decision-making

Data has emerged as the most asset in driving growth and innovation. Industry leaders must:

- Invest in robust data collection, storage, and analysis systems
- Use predictive analytics and AI to uncover actionable insights and optimize operations
- Break down silos to ensure data flows seamlessly across departments, enabling informed decision-making
- Organizations that harness the power of data will gain a significant competitive edge

3. Cybersecurity is non-negotiable

As businesses digitize, they become increasingly vulnerable to cyber threats. Leaders must adopt a proactive approach to cybersecurity by:

- Implementing Zero Trust architectures to minimize unauthorized access
- Investing in advanced threat detection and response tools powered by AI
- Ensuring compliance with global regulations like GDPR and CCPA
- A single breach can damage reputation, erode customer trust, and result in financial losses–making cybersecurity a top priority

4. Agility and innovation drive success

The pace of change in technology and markets demands agility. Leaders must foster a culture of experimentation and continuous improvement by:

- Encouraging teams to test new ideas through pilot projects and iterative development
- Embracing emerging technologies like generative AI, IoT, and blockchain to stay ahead of trends
- Partnering with start-ups, tech providers, and research institutions to co-create innovative solutions
- Agility ensures businesses can adapt quickly to disruptions and seize emerging opportunities

5. Collaboration accelerates transformation

No organization can achieve digital transformation alone. Leaders must build ecosystems that support shared growth by:

- Engaging in public-private partnerships to develop scalable digital infrastructure

- Participating in industry consortia to address common challenges and drive standards

- Mentoring MSMEs and start-ups to create inclusive, resilient supply chains

- Collaboration amplifies impact and accelerates progress for all stakeholders

6. Sustainability is a strategic imperative

Digital tools offer unprecedented opportunities to align profitability with sustainability. Leaders should:

- Use IoT and AI to monitor and reduce energy consumption, waste, and emissions

- Adopt circular economy principles to design sustainable products and processes

- Report on ESG (Environmental, Social, Governance) metrics to demonstrate commitment to responsible practices

- Sustainability not only benefits the planet but also enhances brand reputation and attracts conscious consumers

7. Leadership sets the tone

Ultimately, the success of digital transformation hinges on leadership. Industry leaders must:

- Champion the vision and communicate its importance to all levels of the organization

- Allocate resources strategically, balancing short-term wins with long-term investments

- Foster a culture of lifelong learning to equip employees with the skills needed for the digital era

- Leaders who embrace this responsibility will inspire their teams to embrace change and unlock the full potential of digital transformation

Future trends and emerging opportunities

As we stand on the brink of a new era of digital innovation, transformative trends are set to redefine industries and create unprecedented opportunities for businesses. These trends not only address current challenges but also pave the way for sustainable growth, inclusivity, and resilience in an increasingly interconnected world.

1. Generative AI and compound systems

Generative AI is poised to revolutionize industries by enabling machines to create, simulate, and optimize complex processes. Beyond standalone Large Language Models (LLMs), the integration of compound AI systems—combining generative AI with robotics, IoT, and analytics—will unlock new possibilities. For instance, AI-driven design tools can accelerate product development, while virtual agents will transform customer service and knowledge work. The falling cost of AI technologies makes these innovations accessible even to small businesses, levelling the playing field and fostering creativity.

2. Localized digital solutions

The rise of Indic AI ecosystems and regional language support represents a significant opportunity for inclusivity and economic empowerment. By developing AI models tailored to local languages, dialects, and cultural contexts, businesses can tap into underserved markets and bridge the digital divide. This trend is particularly relevant for MSMEs in emerging economies, where localized solutions can drive financial inclusion and enhance user engagement.

3. Sustainability through digital tools

Sustainability is no longer optional—it is a business imperative. Digital technologies like IoT, blockchain, and AI are becoming critical enablers of green initiatives. For example, smart sensors can monitor energy consumption

and reduce waste, while blockchain ensures transparency in supply chains. Companies that embed sustainability into their digital strategies will not only meet regulatory requirements, but also appeal to environmentally conscious consumers and investors.

4. Decentralized marketplaces

Blockchain technology is giving rise to decentralized marketplaces that eliminate intermediaries, reduce costs, and enhance trust. These platforms enable peer-to-peer transactions, making it easier for MSMEs to access global markets. Additionally, decentralized finance (DeFi) solutions are democratizing access to capital, empowering smaller players to scale their operations without traditional banking constraints.

5. Edge computing and 5G networks

The proliferation of edge computing and 5G networks will transform how data is processed and utilized. By enabling real-time insights at the source, these technologies will enhance applications such as autonomous vehicles, remote healthcare, and smart manufacturing. For industries reliant on speed and precision, edge computing offers a competitive advantage, reducing latency and improving decision-making.

6. Human-AI collaboration

The future of work lies in collaboration between humans and AI. As AI takes over repetitive and mundane tasks, human workers can focus on higher-value activities like strategy, creativity, and problem-solving. This shift will lead to a more productive and engaged workforce, driving innovation across sectors. Upskilling employees to work alongside AI will be crucial for organizations aiming to maximize this synergy.

7. Immersive experiences with AR/VR

Augmented reality (AR) and virtual reality (VR) are redefining customer experiences and operational efficiency. In retail, AR allows customers to visualize products in real-world settings, while VR enhances training programs by simulating realistic scenarios. For manufacturers, these technologies streamline design processes and improve maintenance workflows, offering both cost savings and enhanced outcomes.

8. Cybersecurity evolution

As digital adoption grows, so does the sophistication of cyber threats. Future trends in cybersecurity include AI-powered threat detection, biometric authentication, and quantum encryption. Organizations must adopt proactive measures like Zero Trust architectures and continuous monitoring to safeguard their assets and maintain customer trust.

A call to action for emerging digital transformations

To navigate digital transformation effectively, adopting a 'start small, scale fast' approach is key. Begin with focused pilots, assess their success, and quickly scale proven solutions across the organization. This roadmap provides a clear, phased strategy to guide businesses from initial assessment to sustained digital leadership.

Below is a phased approach tailored for industry leaders, MSMEs and traditional companies:

Phase 1: Assess and strategize (0–6 Months)

1. Conduct a digital readiness assessment:

■ Evaluate current digital maturity levels across processes, technologies, and workforce skills

■ Identify gaps and areas of opportunity

2. Define clear objectives:

■ Align digital initiatives with overarching business goals (e.g., cost reduction, revenue growth, customer satisfaction)

■ Set measurable KPIs to track progress

3. Build leadership buy-in:

■ Ensure top management understands the importance of digital transformation and commits resources.

■ Appoint a Chief Digital Officer (CDO) or Transformation Leader to oversee the initiative.

4. Engage stakeholders:

■ Involve employees, customers, and partners in the planning process to ensure buy-in and address concerns.

Phase 2: Pilot and Scale (6–18 Months)

1. Start small with high-impact pilots:

■ Implement proof-of-concept projects in key areas like automation, predictive maintenance, or personalized marketing

■ Use these pilots to test solutions, gather feedback, and refine strategies

2. Invest in core technologies:

■ Deploy foundational tools such as cloud computing, IoT sensors, and AI-powered analytics platforms

■ Strengthen cybersecurity measures with Zero Trust frameworks and regular audit

3. Upskill the workforce:

- Provide training programs on digital tools, data literacy, and emerging technologies

- Foster a culture of continuous learning and innovation

4. Leverage partnerships:

- Collaborate with tech providers, start-ups, and industry consortia to access expertise and shared resources

Phase 3: Optimize and innovate (18–36 Months)

1. Scale successful initiatives:

- Expand proven solutions across the organization, ensuring seamless integration with existing systems

- Monitor performance metrics and adjust strategies as needed

2. Embrace advanced technologies:

- Explore cutting-edge innovations like generative AI, Digital Twins, and blockchain to unlock new efficiencies and revenue streams

- Experiment with decentralized platforms and edge computing for real-time insights

3. Focus on customer experience:

- Use AI and analytics to deliver hyper-personalized offerings and omnichannel engagement

- Continuously gather customer feedback to refine products and services

4. Drive sustainability:

- Integrate green technologies and circular economy principles into operations.

- Report progress on ESG (Environmental, Social, Governance) goals to build trust with stakeholders.

Phase 4: Sustain and lead (Beyond 36 Months)

1. Embed digital DNA:

- Make digital transformation a core part of the organizational culture, ensuring it evolves alongside market trends

- Encourage experimentation and reward innovative ideas

2. Stay ahead of trends:

- Keep abreast of emerging technologies and industry disruptions

- Participate in global forums and collaborate with thought leaders to shape the future of your sector

3. Measure and celebrate success:

- Regularly review KPIs and celebrate milestones to maintain momentum

- Share success stories internally and externally to inspire others

4. Give back to the ecosystem:

- Mentor start-ups and MSMEs in your network

- Contribute to building shared digital infrastructure and inclusive ecosystems

Digital transformation is a continuous journey, not a destination. This roadmap provides a path from assessment to sustained leadership, turning challenges into opportunities for growth, resilience, and innovation.

By embracing agility, leveraging emerging technologies, and fostering a digital-first culture, businesses can future-proof operations and drive sustainable, inclusive progress. The journey starts today—one step at a time.

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6th Floor, Plot No- 178-178A
Industrial & Business Park, Phase-I
Chandigarh - 160 002
Tel: + 91 172 6717800

Chennai
6th & 7th Floor, A Block,
Tidel Park, No.4, Rajiv Gandhi Salai
Taramani, Chennai - 600 113
Tel: + 91 44 6654 8100

Delhi NCR
Aikyam
Ground Floor
67, Institutional Area
Sector 44, Gurugram - 122 003
Haryana
Tel: +91 124 443 4000

3rd & 6th Floor, Worldmark-1
IGI Airport Hospitality District
Aerocity, New Delhi - 110 037
Tel: + 91 11 4731 8000

4th & 5th Floor, Plot No 2B
Tower 2, Sector 126
Gautam Budh Nagar, U.P.
Noida - 201 304
Tel: + 91 120 671 7000

Hyderabad
THE SKYVIEW 10
18th Floor, "SOUTH LOBBY"
Survey No 83/1, Raidurgam
Hyderabad - 500 032
Tel: + 91 40 6736 2000

Jaipur
9th floor, Jewel of India
Horizon Tower, JLN Marg
Opp Jaipur Stock Exchange
Jaipur, Rajasthan - 302018

Kochi
9th Floor, ABAD Nucleus
NH-49, Maradu PO
Kochi - 682 304
Tel: + 91 484 433 4000

Kolkata
22 Camac Street
3rd Floor, Block 'C'
Kolkata - 700 016
Tel: + 91 33 6615 3400

Mumbai
14th Floor, The Ruby
29 Senapati Bapat Marg
Dadar (W), Mumbai - 400 028
Tel: + 91 22 6192 0000

5th Floor, Block B-2
Nirlon Knowledge Park
Off. Western Express Highway
Goregaon (E)
Mumbai - 400 063
Tel: + 91 22 6192 0000

3rd Floor, Unit No 301
Building No. 1
Mindspace Airoli West (Gigaplex)
Located at Plot No. IT-5
MIDC Knowledge Corridor
Airoli (West)
Navi Mumbai - 400708
Tel: + 91 22 6192 0003

Altimus, 18th Floor Pandurang
Budhkar Marg Worli, Mumbai - 400
018 Tel: +91 22 6192 0503

Pune
C-401, 4th Floor
Panchshil Tech Park, Yerwada
(Near Don Bosco School)
Pune - 411 006
Tel: + 91 20 4912 6000

10th Floor, Smartworks
M-Agile, Pan Card Club Road
Baner, Taluka Haveli
Pune - 411 045
Tel: + 91 20 4912 6800

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