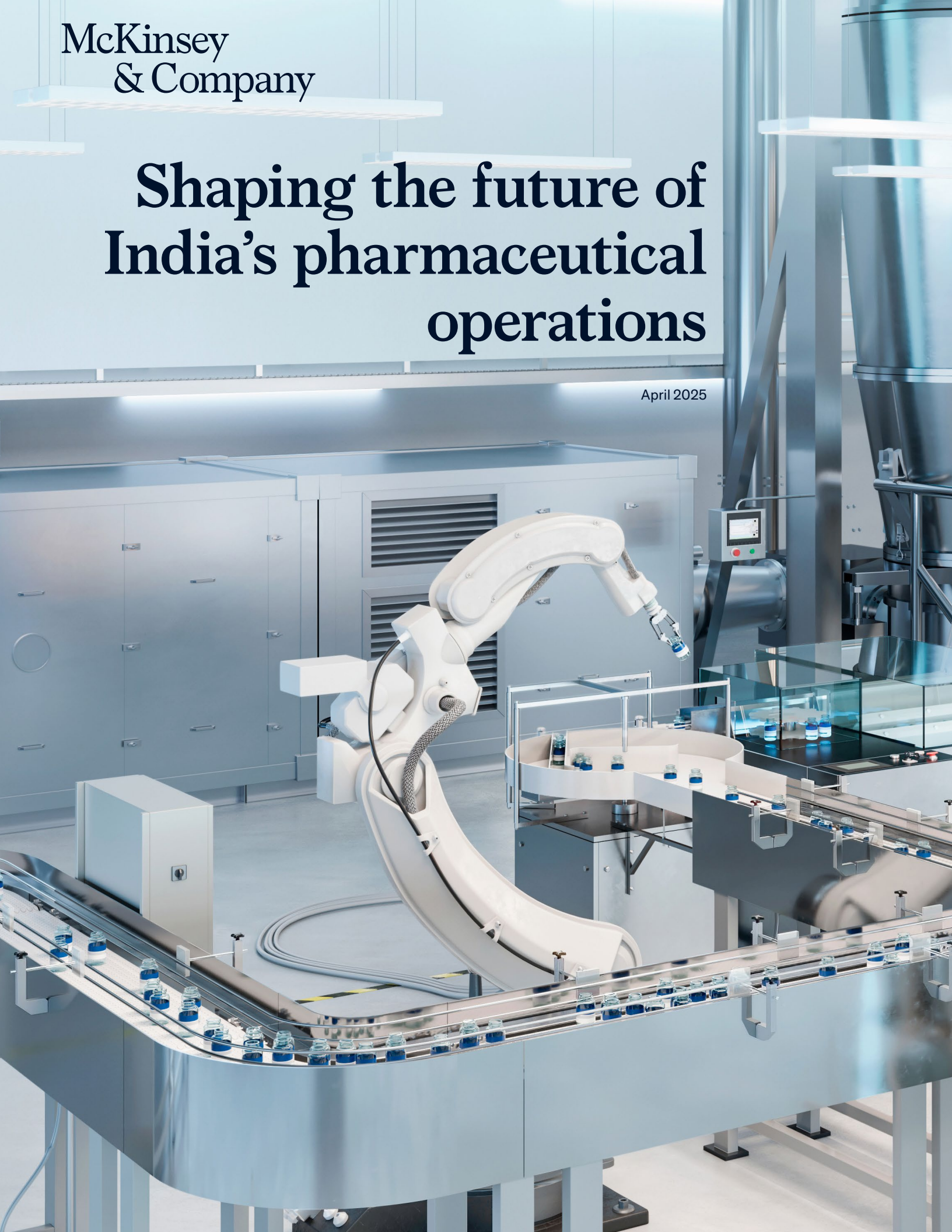


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Shaping the future of India's pharmaceutical operations

April 2025



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Executive summary

Over the past decade and more, India's pharmaceutical sector has become the world's largest supplier of generic medicines, with exports growing faster than the global average. The industry is at a tipping point, however: the Indian and global landscapes are shifting. While emerging trends could disrupt the current environment, they could also lead to the next horizon of opportunities for the industry.

Against this backdrop, what will it take for the industry to achieve its full potential and unlock the next S-curve of performance as a global leader? To answer the question, this report looks at Indian pharma's journey so far, highlights the potential disruptions and opportunities likely ahead, and proposes strategic, thematic priorities for pharma companies as they pursue accelerated and sustained global leadership.

The evolution of India's pharmaceutical operations: Triumphs and trials

With emphasis on strong operations over the past decade, Indian pharma production has outpaced global growth by over two times, and Indian exports (at 9 percent) have outpaced global growth (5 percent).¹ Five factors have contributed to this performance:

1. **Increased investments in infrastructure.** India has a manufacturing infrastructure of 752 Food and Drug Administration (FDA)–approved sites, 2,050 World Health Organization (WHO) Good Manufacturing Practice (GMP)–certified plants, and 286 European Directorate for the Quality of Medicines and Healthcare (EDQM)–approved plants as of 2024.²
2. **Enhancing quality to meet global standards.** Global compliance outcomes have improved over the past decade, and the industry achieved a step change in its quality excellence trajectory.
3. **Leadership in cost and operational efficiencies.** Manufacturing costs in India have stayed 30 to 35 percent lower than in the United States and Europe, because of structurally low-cost labor, collective efforts to achieve industry-leading cost and productivity performance, and accelerated digital adoption.
4. **Expanded capabilities across the value chain.** India has also enhanced its position in the operations value chain by demonstrating broader capabilities across more complex dosages and large molecules.
5. **Sustained reliability and structural resilience.** The Indian pharma industry has worked at fostering self-reliance and building strong supply-chain networks. This supported the industry to consistently and reliably maintain essential supplies in critical times such as the COVID-19 pandemic between 2020 and 2022.

Trends likely to have impact on the operations landscape

The industry now stands at a crossroads, with internal and external disruptions poised to create a shifting landscape (Exhibit 1). Within the industry, performance has started plateauing while the bar for quality excellence continues to rise. Disruptions such as the next generation of digital technologies, smart automation, and new modalities or therapies could reshape traditional plant operations.

In the external environment, an even more complex set of forces is shaping the landscape. Geopolitical uncertainties and nearshoring could challenge current operations strategies. Sustainability in operations is fast becoming a critical business enabler for companies. New opportunities could arise and scale up, such as pharma services or contract development and manufacturing organizations (CDMOs) and emerging markets.

Purposeful moves that build on the tailwinds and address the headwinds could help companies to remain ahead in this ever-evolving global market.

¹BMI, a Fitch solutions company, 2024.

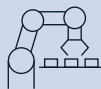
²Generic drug facilities, sites, and organization lists," US Food and Drug Administration (FDA); *Indian Pharmaceutical Sectorial System of Innovation (IPSSI)*, United Nations Industrial Development Organization (UNIDO) and Government of India Department of Science and Technology, March 2023.

Exhibit 1

Various trends are likely to impact the operations landscape.

Trends shaping internal operations networks in India

- A** Plateauing performance improvements
- B** Evolving bar on quality excellence in plant operations
- C** Disruptions in digital technologies and accelerating adoption rates
- D** Evolution of core manufacturing infrastructure and smart automation
- E** Shift toward the next generation of therapies



Evolution and disruptions in the external environment

- F** Geopolitical risks and discontinuities
- G** Emerging pockets of geographic nearshoring
- H** Growth of emerging markets beyond the US, Europe, and India
- I** Environmental sustainability becoming the right to do business
- J** Global tailwinds boosting pharma CDMO¹ and services



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Themes for the future of Indian pharmaceutical operations

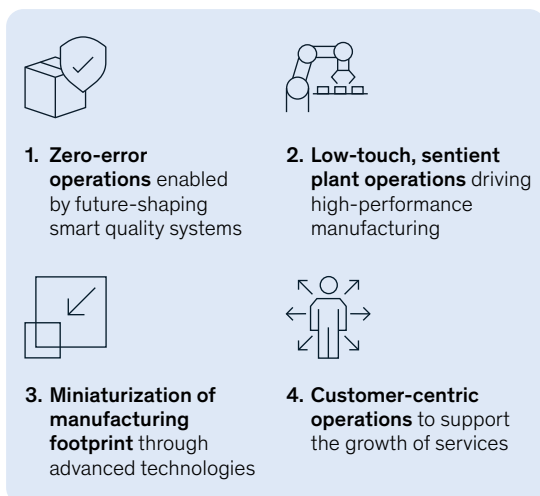
Over the next decade, companies will need to fundamentally redefine their operational strategies. With a focus on eight core priorities, the pharma industry could build agile, efficient, reliable, and sustainable operations for the future (Exhibit 2).

1. **Zero-error operations enabled by future-shaping smart quality systems.** These could effect a fundamental shift from reactively resolving issues to proactively preventing defects and from merely reducing errors to structurally eliminating them. This could unlock industry-best outcomes such as over 99.9 percent right-first-time performance, less than 0.01 percent batch failures and deviations, eight-sigma process capability, and zero repeat errors, among others.
2. **Low-touch, sentient plant operations driving high-performance manufacturing.** Intelligent systems could autonomously manage and optimize manufacturing operations to eliminate human error and enhance overall quality, over and above a potential, repeatable step change in efficiency (such as manufacturing cost reductions of more than 40 percent, overall equipment effectiveness [OEE] consistently exceeding 70 percent, a doubling of productivity, and plant downtimes reduced by 70 percent).
3. **Miniaturization of manufacturing footprint through advanced technologies.** New possibilities of continuous manufacturing, modular “plant-in-plant” setups, and small-scale operations or microreactors for higher reliability, especially in biopharma manufacturing, could all contribute to modular but high-performance delivery.
4. **Customer-centric operations to support the growth of services.** With purposeful shifts, emerging companies could fully unlock the CDMO opportunity, such as by broadening portfolio and capabilities, cultivating a customer-centric operations excellence model, streamlining operations for cost efficiency, attracting and retaining top operations talent, and continuing a focus on capacity expansion.
5. **The next horizon of expanded enterprise-wide cost leadership.** In the face of operational plateaus, companies could target the next S-curve of cost leadership through a focus on four themes:

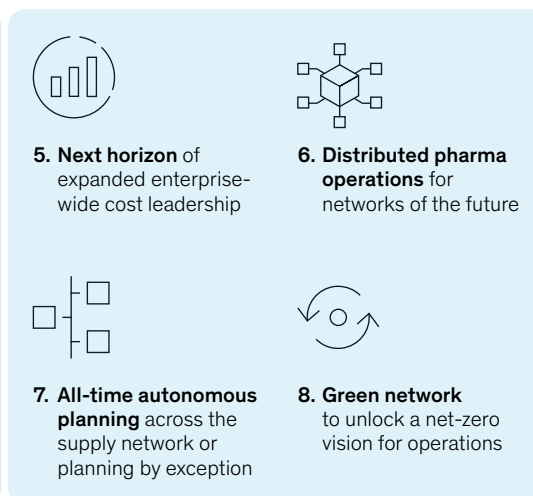
Exhibit 2

Eight priority themes could shape the next decade of pharmaceutical operations.

Plant-level focus areas



Network-wide priorities



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attaining the same level of cost leadership in large molecules as in small molecules, exploring deep de novo scientific optimization for API/KSM (active pharmaceutical ingredient/key starting material) manufacturing, attaining a last-person-standing position in their hero product, and unlocking the next wave of procurement excellence.

6. ***Distributed pharma networks of the future.*** As part of their network strategy, companies could think about establishing centers of excellence (COEs) and distributing their manufacturing footprint. These COEs could help to navigate both the increasing complexity of global pipelines and emerging pockets of regionalization.
7. ***All-time autonomous planning across the supply network.*** Planning by exception, where companies will need to embed AI/ML (artificial intelligence/machine learning) or digital principles in day-to-day supply chains to unlock new levels of performance, such as planning and inventory cost reductions of more than 30 percent, service levels above 98 percent across the network, and lead times shortened by around 25 to 40 percent.
8. ***Green network to unlock a net-zero vision for operations.*** Organizations could start adopting an integrated dual-mission approach, to drive cost optimization across spend items while optimizing their Scope 3 footprint. They could target win–win approaches to cut costs and carbon dioxide emissions, such as raw-material value chain decarbonization, process and energy efficiency, recycling and circulating, package/product redesign, and sustainable supply collaboration.

India's pharmaceutical industry stands strong today because of what it has built over the last decade. It can further accelerate its global leadership even with significant disruptions on the horizon. On the brink of a pathbreaking S-curve, it could boost growth and profitability, achieve industry-leading quality and sustainability, and drive greater innovation. The priorities outlined here could serve as a guide for pharmaceutical companies as they pursue taking this potential to reality.

CHAPTER 1

The evolution of India's pharmaceutical operations: Triumphs and trials



India's pharmaceutical industry has been working over the past decade to grow its presence on the global stage. With emphasis on improving operations, the industry today has broadened access to affordable medicines worldwide and boosted its growth and performance.

A legacy of global growth over the past decade

As of 2024, India is the world's largest supplier of generic drugs, accounting for 20 percent of global volumes,³ including 40 percent of generics demand in the United States and 25 percent of all medicine in the United Kingdom.⁴ The country is now the third-largest global exporter of pharmaceuticals by volume and ranks 11th by value.⁵ Indian pharmaceuticals is also now the second-highest generator of trade surplus (second only to textiles and related products), to the tune of around \$20 billion.⁶ It has an export growth rate of 9 percent, outpacing the global average of 5 percent (Exhibit 3).⁷

The Indian pharma industry has been working to bolster global health security and broadening patient access to care worldwide. As the world's largest vaccine producer, India contributes over 60 percent of the global vaccine supply. Additionally, Indian companies have shaped global HIV treatment by enhancing access to affordable antiretroviral therapy (ART): as of 2024, India provides over 70 percent of the world's antiretroviral medications.⁸

A strong operations backbone has been crucial in this journey. Indian companies' operational capabilities have allowed them to scale up production to meet global demand while keeping costs competitive with the West. This operational excellence has ensured resilience and improved access to care, even during tough times like the COVID-19 pandemic, when supply chains were heavily disrupted.

³Government of India Department of Pharmaceuticals, annual report, FY 2024.

⁴"Pharmaceuticals," India Brand Equity Foundation (IBEF), August 2024.

⁵Trade Statistics, Pharmaceuticals Export Promotion Council of India (Pharmexcil), accessed on February 13, 2025.

⁶Ministry of Commerce and Industry trade statistics portal.

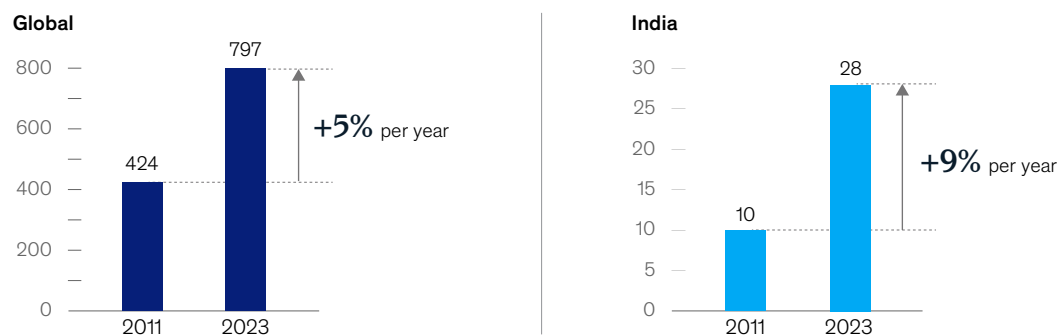
⁷BMI, a Fitch solutions company, 2024.

⁸"India's pharma exports grow over 125% in last 9 years; Investment of Rs. 21,861 crore received under PLI schemes," Government of India Press Information Bureau, June 13, 2023.

Exhibit 3

Indian exports grew faster than the global average over the past decade.

Pharmaceutical exports, \$ billion



¹To annualize to a like-to-like number, the export numbers of India have been phased by a quarter (eg, FY 2024 numbers taken for 2023). Source: BMI, a Fitch solutions company, 2024; Pharmexcil trade statistics

Over the past ten years, production in India has grown at a rate of about 8 percent, outpacing global production by over two times (Exhibit 4).⁹ This growth has been broadly based across different modalities and platforms. This is evident in the scaling of active pharmaceutical ingredient (API) production, where India now accounts for over 8 percent of global volumes,¹⁰ and biotechnology, where India ranks 12th in the world, commanding 3 to 5 percent of the global market.¹¹

A five-dimensional transformation

The past few years have been transformative for pharma operations, with five major themes propelling India's performance:

A. Investing in world-class manufacturing infrastructure

Indian pharma companies have strengthened their operations infrastructure to support their growth aspiration through structured capacity expansion.

⁹India's pharma exports grow over 125% in last 9 years; Investment of Rs. 21,861 crore received under PLI schemes," Government of India Press Information Bureau, June 13, 2023.

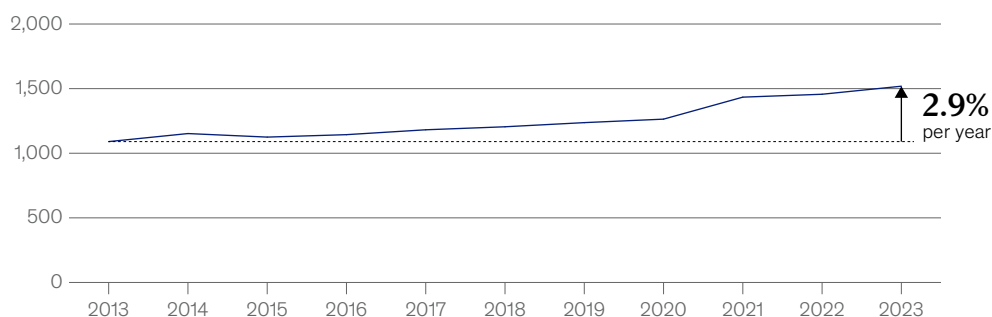
¹⁰Government of India Department of Pharmaceuticals, annual report, FY 2024.

¹¹ "Pharmaceuticals," India Brand Equity Foundation (IBEF), August 2024.

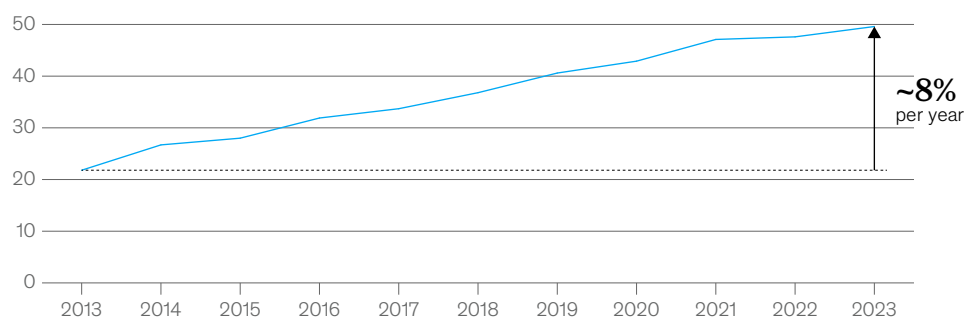
Exhibit 4

India's pharmaceutical production market grew at twice the global rate over the last decade.

Global pharmaceutical market, \$ billion



Indian pharmaceutical production, \$ billion



Indian production share of global market, %

Year	Indian production share of global market, %
2013	2.0
2014	2.3
2015	2.5
2016	2.8
2017	2.9
2018	3.1
2019	3.3
2020	3.4
2021	3.3
2022	3.3
2023	3.3

Source: BMI, a Fitch solutions company, 2024

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The country has a manufacturing infrastructure with 752 Food and Drug Administration (FDA)–approved sites,¹² 2,050 World Health Organization (WHO) Good Manufacturing Practice (GMP)–certified plants, and 286 European Directorate for the Quality of Medicines and Healthcare (EDQM)–approved plants in 2024,¹³ the highest globally (Exhibit 5). It has continued to expand its capacity. For instance, in 2024, India added 20 new FDA-approved generic units for making APIs and/or finished dosage forms (FDFs).¹⁴

B. Enhancing quality to meet global standards

Over the years, Indian companies have made significant investments to build systems, processes, capabilities, and culture that meet or exceed international standards. For instance, organizations now adopt a continuous quality improvement mindset by supporting a culture of quality and competency building across levels. Companies have also started leveraging analytics at scale to minimize product variability, eliminate lab errors, and guide investigations.

The quality outcomes have included a 50 percent reduction in Official Action Indicated (OAI) outcomes from FDA inspections in the last ten years and a 27 percent reduction in European Medicines Agency noncompliance between 2013–14 and 2023–24.¹⁵ In 2023–24, the proportion of OAI outcomes originating from Indian manufacturing facilities also fell below those in international locations.¹⁶

A collaborative effort to raise the collective bar (rather than targeting isolated excellence) has been a core enabler in the industry’s rise to global prominence. Over 20 local, regional, and national industry associations have facilitated this collaboration, driving improvements through best-practice development and sharing, innovation networks with academia, and policy advocacy.

¹²“Generic drug facilities, sites, and organization lists,” US Food and Drug Administration (FDA).

¹³*Indian Pharmaceutical Sectorial System of Innovation (IPSSI)*, United Nations Industrial Development Organization (UNIDO) and Government of India Department of Science and Technology, March 2023.

¹⁴“India continues to top FDA-registered generics facilities, sets up 20 new units for FY24,” *Pharma Compass*, November 2023.

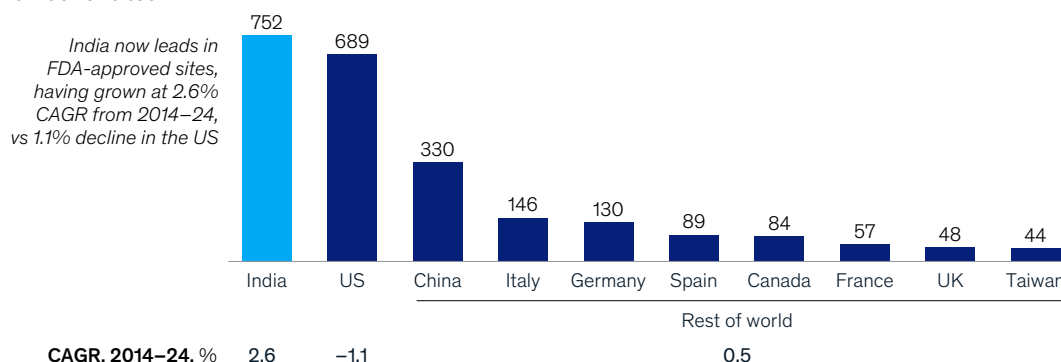
¹⁵FDA inspection database and EMA annual reports.

¹⁶FDA inspection database.

Exhibit 5

India has the highest number of FDA-registered generic manufacturing sites.

FDA-registered generic API¹ and FDF² manufacturing and testing sites across top countries, 2024,
number of sites



¹Active pharmaceutical ingredient.

²Finished dosage form.

Source: “Generic drug facilities, sites, and organization lists,” US Food and Drug Administration

C. Driving leadership in cost and operational efficiencies

Indian manufacturing costs have remained 30 to 35 percent lower than those in the United States and Europe.¹⁷ While structural factors such as low labor and utility costs have always been strong tailwinds for India, companies have also invested in efficiency enhancements over the years through initiatives such as adopting lean Six Sigma practices and process improvements such as yield enhancement and solvent recovery.

Indian companies also leverage digital technologies and AI to enhance productivity, cost, and efficiency. The Indian pharma industry is emerging as a fast follower in technology adoption. The World Economic Forum (WEF) recognized the first set of Indian pharma companies as advanced Fourth Industrial Revolution (4IR) lighthouses between 2022 and 2024. As of December 2024, India has the highest number of pharma 4IR lighthouses globally.¹⁸

POBOS (McKinsey's proprietary pharma benchmark) shows labor productivity has increased by 24 percent from 2014 to 2023 against 20 percent globally, and on-time-in-full (OTIF) delivery has risen by over 40 percent, compared with 1 percent globally (Exhibit 6). Additionally, conversion costs have fallen by 20 to 25 percent and logistics costs by 15 to 20 percent over the past five years.

D. Expanding capabilities across the value chain

Through the past several decades, India's pharma companies have significantly evolved their operations capabilities by broadening their reach across the value chain. Initially focused on relatively simpler products such as tablets and capsules, the sector has now also diversified into complex platforms, including

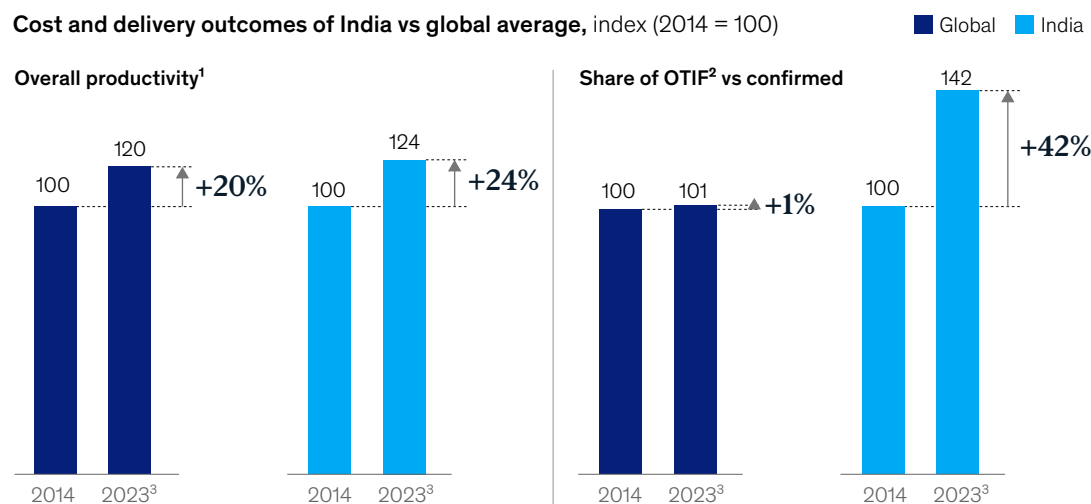
¹⁷Pharmaceuticals Industry Report, IBEF, August 2024.

¹⁸"Global Lighthouse Network," World Economic Forum.

Exhibit 6

Labor productivity and 'on time in full' delivery outcomes have increased between 2014 and 2023.

Cost and delivery outcomes of India vs global average, index (2014 = 100)



¹Measured in million units per full-time employee.

²On time in full.

³Average of 2022 and 2023 taken for cost and delivery outcome metrics due to limited data availability for 2023.

Source: POBOS (McKinsey's proprietary pharma benchmark)

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injectables, inhalation, peptides, and biosimilars, and made early strides into antibody-drug conjugates (ADCs), and oligonucleotides.

This has enabled India to enhance its position in the pharma production network, evidenced by the increase in approved biosimilars from 14 in 2005¹⁹ to over 138 in 2023.²⁰ There has been a significant rise in the share of complex dosage forms (topicals, injectables, nasal, ophthalmic, et cetera) among ANDA approvals from Indian companies, from 25 percent in 2013 to 30 percent in 2023.²¹ This progress is further highlighted by pioneering achievements, such as India developing the world's first FDA-approved biosimilar for insulin glargine.²²

E. Building reliability and structural resilience

The industry has maintained consistent growth against a backdrop of geopolitical uncertainties through proactive measures.

Supported by local policies such as production-linked incentive (PLI) schemes, Indian pharma players have expanded API capacities to become self-reliant. For example, between 2022 and 2024, Indian companies started producing 38 local APIs that had previously been imported.²³ Companies have also been successful in derisking their supply chains and enhancing their robustness through dual sourcing, increasing supply flexibilities, and building in-house supply redundancies.

The COVID-19 pandemic tested this resilience. However, India's pharma exports grew by 9 percent between 2019 and 2022 despite an 8.5 percent drop in the Index for Industrial Production (IIP),²⁴ restricted transportation, disrupted supply chains, and a global labor crisis.²⁵ While the pandemic strained the availability of medical supplies in the country, the industry continued to maintain supplies of essential medicine, scaled up production of critical COVID-19 drugs such as remdesivir, favipravir, and hydroxychloroquine, and delivered 300 million doses of COVID-19 vaccines to over 100 countries between 2021 and 2023.²⁶

A continued emphasis on such resilience and adaptability will be important for the industry as geopolitical disruptions are expected to become the new normal, with more than 65 percent of top leaders believing it to be the top risk to global growth.²⁷

Over the last ten years, the Indian pharma industry has made significant progress. The next decade will present a complex landscape of emerging and evolving challenges and opportunities. The industry will require foresight and decisive action to navigate these dynamics for sustained growth and resilience.

¹⁹Rajiv Kumar and Jagjit Singh, "Biosimilar drugs: Current status," *International Journal of Applied & Basic Medical Research*, July–December 2014, Volume 4, Number 2.

²⁰Central Drugs Standard Control Organisation database, August 2023.

²¹Drugs@FDA: FDA-Approved Drug Products, US Food and Drug Administration, accessed on February 13, 2025.

²²"A century of insulins," Biocon Biologics, 2025.

²³"India has started manufacturing 38 APIs in past 1.5 years: Mandaviya," *Business Standard*, August 5, 2023.

²⁴"Index of Industrial Production (IIP)," Government of India Ministry of Statistics and Programme Implementation (MoSPI).

²⁵Export Products (Pharmaceuticals), Government of India Ministry of Commerce and Industry.

²⁶"India's pharma exports grow over 125% in last 9 years; Investment of Rs. 21,861 crore received under PLI schemes," Government of India Press Information Bureau, June 13, 2023.

²⁷Jeffrey Condon, Krzysztof Kwiatkowski, and Sven Smit, "Economic Conditions Outlook 2024," McKinsey, March 2024.

CHAPTER 2

Trends likely to have impact on the operations landscape



Performance improvements across Indian pharmaceutical plant networks are starting to show signs of plateauing, while the bar for quality excellence continues to rise higher. Several forces are likely to reshape traditional plant operations, such as disruptions in digital technologies, the evolution of smart automation, and the transition toward next-generation therapies and new modalities.

These evolving networks will face a more complex set of forces: Geopolitical uncertainties could occur more frequently, with some pockets of nearshoring starting to emerge. Beyond the United States, Europe, and India, broader emerging markets will grow as value pools. Sustainability in operations will emerge as a right to do business. And global trends could fuel the growth of Indian contract development and manufacturing organizations (CDMOs).

These trends shaping internal operations networks in India and disruptions in the external environment are propelling the pharma industry to the threshold of a transformative era (Exhibit 7).

Trends shaping internal operations networks in India

Within the pharma industry, performance has started plateauing while the bar for quality excellence continues to rise. Disruptions such as the next generation of digital technologies, smart automation, and new modalities or therapies could reshape traditional plant operations.

A. Plateauing performance improvements

While India's pharmaceutical operations have improved in recent years, performance improvements are starting to plateau as traditional operational excellence levers reach their full potential (Exhibit 8).²⁸

To break through this stagnation and ride the next wave of performance improvements, pharma companies could need proactive measures to achieve the next S-curve of plant operations leadership.

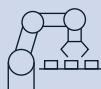
²⁸POBOS (McKinsey's proprietary pharma benchmark).

Exhibit 7

Various trends are likely to impact the operations landscape.

Trends shaping internal operations networks in India

- A** Plateauing performance improvements
- B** Evolving bar on quality excellence in plant operations
- C** Disruptions in digital technologies and accelerating adoption rates
- D** Evolution of core manufacturing infrastructure and smart automation
- E** Shift toward the next generation of therapies



Evolution and disruptions in the external environment

- F** Geopolitical risks and discontinuities
- G** Emerging pockets of geographic nearshoring
- H** Growth of emerging markets beyond the US, Europe, and India
- I** Environmental sustainability becoming the right to do business
- J** Global tailwinds boosting pharma CDMO¹ and services

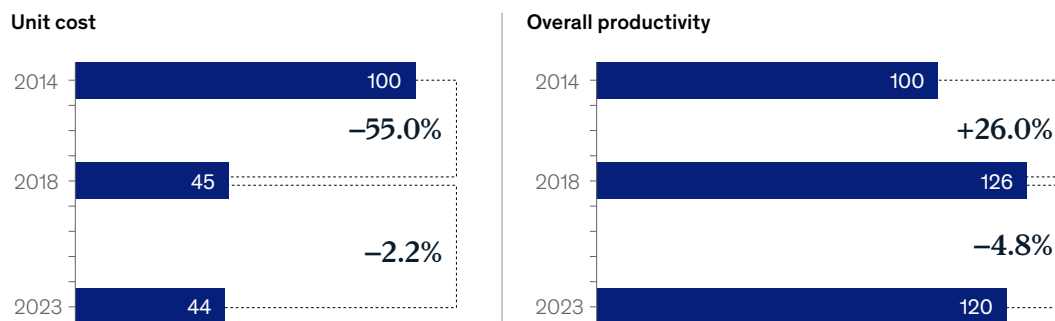


¹Contract development and manufacturing organization.

Exhibit 8

Improvement in global cost and productivity has gradually plateaued in the past five years.

Unit cost and overall productivity, global, index (2014 = 100)



Note: Figures may not sum, because of rounding.
Source: POBOS (McKinsey's proprietary pharma benchmark)

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B. Evolving expectations for quality excellence in plant operations

While the industry has already made significant investments to enhance standards, expectations continue to evolve. This evolution is reflected in guidelines and best practices periodically published by regulators; for example, the FDA's quality management maturity (QMM) framework cuts across quality culture, advanced quality management practices, and enhanced supply chain reliability, encouraging continuous improvement to minimize risks to product availability.²⁹

An analysis of FDA inspections also demonstrates an evolution of the big focus areas under global compliance. Core Current Good Manufacturing Practices (CGMP) capabilities, process controls, and data integrity were dominant areas a decade ago, but these have seen a 3 to 4 percent reduction in FDA inspections over the past six years. In recent years, there is an increased focus on gaps in practices versus written procedures, facility maintenance and infrastructure, and investigations quality (root-cause analysis and corrective and preventive actions [CAPAs]).³⁰

As the quality landscape continues to evolve, Indian pharma companies must adapt to new compliance expectations and fundamentally shift their ways of working for sustained, ahead-of-the-curve quality performance.

C. Disruptions in digital technologies and accelerating adoption rates

About 55 percent of pharma firms now integrate digital and AI tools in everyday operations.³¹ However, the rapid evolution of technology is expected to present several new opportunities for the industry. Two significant developments could transform the future technology landscape:

- **Platformization or democratization AI.** Platformization or democratization AI has the potential to enhance digital adoption across organizations and the industry. It involves deploying low-code and no-code platforms that leverage advanced digital capabilities with limited or no in-house technical

²⁹"CDER quality management maturity," US Food and Drug Administration.

³⁰Inspections, FDA Dashboards, US Food and Drug Administration.

³¹Jennifer Sexton, "Digital transformation in pharma: Improving R&D through digital solutions," *CAS Insights*, September 5, 2023.

expertise. Such platforms facilitate rapid and scalable deployment of advanced analytics with minimal manual intervention. Numerous use cases have emerged that illustrate the impact of this democratization (Exhibit 9).

- *The rise of gen AI.* Gen AI has the potential to unlock \$60 billion to \$110 billion additional revenue in pharmaceuticals while increasing profit margins by four to seven percentage points.³² While gen AI

³²“Early adoption of generative AI in commercial life sciences,” McKinsey, May 6, 2024.

Exhibit 9

A suite of integrated applications of low code/no code could be deployed for error-proof and enhanced efficiency.

Illustrative application suite

Lab

Democratized AI/ML¹ micro-insighting platform to minimize lab errors

Low-/no code platform to run lab process simulations and predict most error-prone product-test-analyst combinations and identify best-fit interventions



Invalid OOS²



Lab deviations

Near-real-time proactive supplier risk monitoring platform

Evaluate suppliers' quality vulnerabilities via risk models on internal and external data, eg, continuous comparative market analysis (CMA) analysis, establish correlations with quality (CQA³) risks, etc



Failures due to supplier quality (eg, material, transit)

Shop floor

AI-platform for process simulation to enhance product outcome

Democratized AI platform instituted for process simulation to enhance yield and process capability of critical products and unlock industry leading benchmark levels



Yield loss



Product quality

AI-enabled end-to-end machine efficiency enhancement platform

At-scale IIoT⁴ platform deployed to address the next level of manufacturing inefficiencies affecting overall equipment effectiveness (OEE) performance across granulation, compression, and packaging to achieve industry-leading levels of OEE (in compression)



OEE loss



Machine setting time

End-to-end plant operations

AI-led equipment reliability improvement via a suite of digital instrument and human error detection applications

Visual AI models for identification and prediction of instrument health; ie, failure risk for critical and end-of-life parts



Deviations/errors (for respective equipment/areas)

AI-enabled dynamic scheduling platform

Multivariate daily/shift-level optimization of schedule at an analyst level—based on skill level, in/out time, unplanned leaves, equipment or sample availability, production plan, etc



Productivity



Release time

¹Artificial intelligence/machine learning.

²Out of specification.

³Critical quality attributes.

⁴Industrial internet of things.

Source: McKinsey analysis

adoption in pharmaceuticals has been limited, opportunities across the value chain are immense (Exhibit 10). Use cases across organizations are already reporting considerable benefits, such as over 30 percent improvement in quality outcomes, over 50 percent productivity gains, and 5 to 10 percent cost reductions across the broader network.³³

Both platformization/democratization and gen AI advancements offer more than just performance gains. Early adopters are reaping broader benefits such as enabling real-time transparency and decision-making, improving reliability by reducing human dependence, and increasing the precision of insights. It could be important for pharma companies to capitalize on these technological advancements to help future-proof their long-term strategies.

D. Evolution of core manufacturing infrastructure and smart automation

Core manufacturing technologies in the pharma industry have remained unchanged for decades. For example, tableting is still done through traditional granulation-compression-coating cycles, and material handling and movement continue to be a primarily manual process. This is beginning to shift through recent advancements in core process technologies.

Continuous manufacturing (CM) is a significant disruptor, replacing traditional batch processing with a seamless, nonstop production approach. CM enables advantages such as reduced manufacturing

³³"Generative AI in the pharmaceutical industry: Moving from hype to reality," McKinsey, January 9, 2024.

Exhibit 10

Non-exhaustive

Gen AI can enable several high-impact opportunities across the value chain.

10 illustrative use cases adopted by players

 Procurement 1. Input cost monitoring, parametric clean sheet, and vendor discovery leveraging supplier data and AI models for real-time insights 2. Procurement assistant to enable value capture from negotiation, PR to PO¹ process, and contract management 3. ContractAI to enable automatic contract analysis and generation	 Manufacturing 4. Real-time SOP² assistant to assist queries across all plant SOPs on the go 5. Real-time compliance engine (ie, large language model [LLM] that searches FDA Form 483 filings, guidelines, and third-party data to identify future focus areas for compliance)	 Quality 6. Investigations AI; LLM-enabled assistance for augmenting quality of reports and root causes 7. Image recognition and AI-led investigator to surface "micro-anomalies" in way of working 8. Digital supplier quality suite (eg, real-time risk profiling, online performance management, automated CoA³ generation)	 Supply chain 9. Low-touch demand and supply planning (eg, automated triggers/implications for non-APS⁴ decisions, auto-generated S&OP/DP⁵ as second opinion) 10. Supply chain copilot for S&OE⁶ control tower to enable real-time monitoring, short-term management of deviations from plan, etc
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¹Purchase requisition to purchase order. ²Standard operating procedure. ³Certificate of analysis. ⁴Advanced planning and scheduling. ⁵Sales and operations planning/demand planning. ⁶Sales and operations execution.
Source: Expert interviews

footprint, lower operating costs, and more agile service levels (Exhibit 11). Also, the regulatory acceptance of these technologies is growing, with agencies such as the FDA having already approved over a dozen CM-produced drugs.³⁴ Leading pharma companies are actively crafting a vision for smart automation by integrating efficient, user-centric, technology-enabled processes into daily operations.

On the shop floor, smart automation transforms interface operations including material handling, washing, and cleaning. Such automated systems eliminate inefficiencies in compliance, streamline essential standard operating procedures, and offer intuitive process instructions. Some examples include auto-loading reactors with powder transfer systems for reliability and automated equipment cleaning via cleaning agent valves with protocols integrated into programmable logic controllers (PLCs).

Similarly, in the quality control (QC) lab, technologies are advancing rapidly across testing and nontesting activities to minimize touch time across test campaigns.³⁵ Some examples include a comprehensive lab management suite for efficient planning (automated inventory control, remote instrument monitoring, remote assistance with maintenance and calibration scheduling), decentralized QC with online real-time monitoring and automated control of process parameters, and release-and-review conducted by exception.

These technologies have the potential to disrupt pharma operations at the plant. However, realizing their full potential will require addressing challenges such as high upfront investments, varying QC standards, and aligned supply chains with continuous production timelines. Pharma companies need to consider how these technologies can establish new working methods and realize benefits across interventions.

³⁴Rui Silva, Rui Almeida, Pedro Ferreira, José Cardoso Menezes, and Angela Martinho, "Agile data-driven life cycle management for continuous process verification," *Pharmaceutical Engineering*, July–August 2023.

³⁵POBOS (McKinsey's proprietary pharma benchmark); OSD Top Decile (Global FDA Approved).

Exhibit 11

Continuous manufacturing is a significant enabler to improve pharma manufacturing performance.

Benefits of continuous manufacturing

Up to 50% lower conversion cost, driven by, eg, labor reduction, increased volume per hour, etc

Improved quality via in-line testing as well as elimination of manual handling and human errors



10x lower cycle time, due to, eg, no inventory between process steps and faster batch release through in-line controls, etc

80% reduction in manufacturing footprint, as fewer lines are needed

Source: McKinsey analysis

McKinsey & Company

E. Shift toward the next generation of therapies

Both the product and therapeutic landscapes also are undergoing rapid changes globally. Emerging modalities such as mRNA, cell and gene therapies, antibodies, and peptides and proteins have seen a CAGR of 13 to 14 percent between 2018 and 2023, outpacing the growth of conventional therapies at 5 to 6 percent. In the last two decades, the share of these new modalities in the drug development pipeline has risen from 31 percent to 50 percent. This is the fastest growth ever seen in the sector (Exhibit 12).³⁶

From 2022 to 2030, drug sales amounting to \$251 billion are expected to lose patent protection.³⁷ This loss-of-exclusivity pipeline offers the industry an opportunity to pivot to advanced modalities such as antibody-drug conjugates (ADCs), oligonucleotides, peptides, and monoclonal antibodies. This is further bolstered by the growing importance of mRNA-based vaccines and innovative therapies, projected to achieve a CAGR of about 12 to 13 percent between 2025 and 2030.³⁸

³⁶Pharmaprojects, 2024.

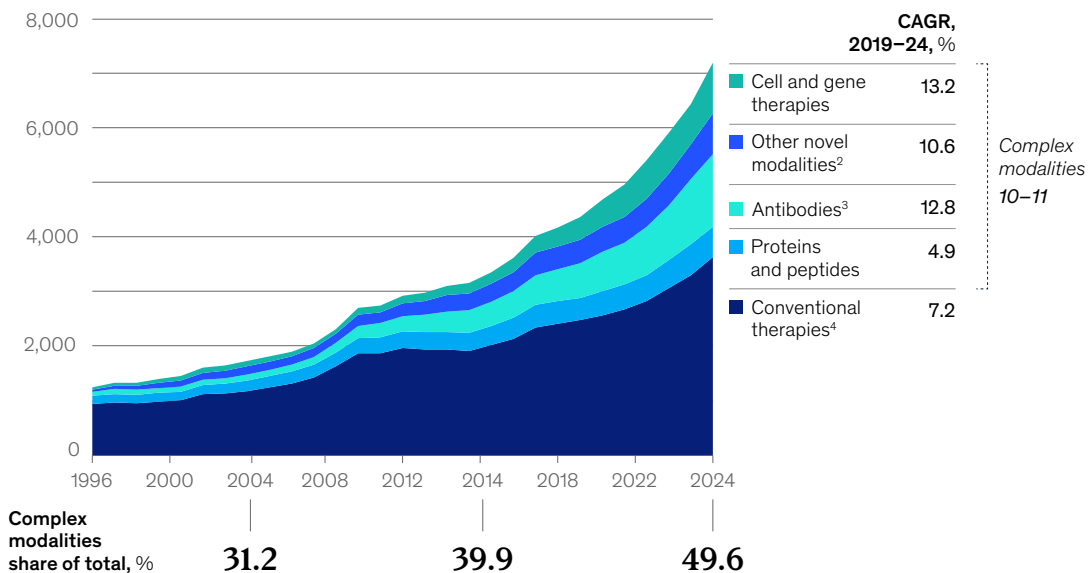
³⁷An analysis on leveraging the patent cliff with drug sales worth USD 251 billion going off-patent and analysis of different drug pricing methodologies for Indian generic pharmaceutical companies, Government of India Department of Pharmaceuticals, Ministry of Chemicals and Fertilizers, August 2023.

³⁸Global mRNA vaccine and therapeutics market, Azoth Analytics, May 2021.

Exhibit 12

The share of complex modalities has steadily grown to represent approximately 50 percent of the global pipeline in 2024.

Size of global pipeline by technology, number of products¹ from Phase I to III



¹Innovative drugs only, excluding reformulations, biosimilars, digital therapeutics, diagnostics and imaging; snapshot as of June each year with missing phases not approximated; phase based on most progressed indication.

²Include nucleotide- and viral-based therapies other than gene therapy and gene editing (mRNA, antisense, lytic viruses, phages), oncology vaccines, and other biologics not classified elsewhere.

³Include monoclonal antibodies, antibody-drug conjugates (ADCs), minimized and multi-specific antibodies.

⁴Include small molecules, anti-infective vaccines, and natural extracts.

Source: Pharmaprojects, Sept 2024

In the face of these shifts, pharma companies may need to develop new capabilities and service offerings, including but not limited to the following:

- *ADCs* require site-specific conjugation methods to enable precise control over the drug-to-antibody ratio.
- *Oligonucleotides, peptide, and protein* production demands solid-phase nucleotide and peptide synthesizers, reverse-phase high-performance liquid chromatography (HPLC), size exclusion chromatography, and other structural and functional analysis techniques.
- *mRNA therapies* will need robust mRNA synthesis and purification processes, lipid nanoparticle formulation technologies for efficient delivery, and cold chain logistics to ensure the stability and efficacy of the mRNA products.
- *Clustered regularly interspaced short palindromic repeats-based therapies* will necessitate capabilities in precise gene-editing techniques, off-target effect minimization, and the development of delivery systems such as viral vectors or nanoparticles.

As the therapeutic landscape evolves with its distinct technical complexities, the industry could need to develop its manufacturing capabilities accordingly and ensure that operations keep pace with the speed of innovation.

Evolution and disruptions in the external environment

A complex set of forces is shaping the external landscape of the pharmaceuticals industry. Geopolitical uncertainties and nearshoring, as well as growing pressure to address sustainability, could prompt the emergence of new opportunities.

F. Geopolitical risks and discontinuities

Over the past decade, geopolitical events and global crises have caused significant supply disruptions. While the industry showed resilience by increasing production and maintaining the availability of essential medications, vaccines, and medical supplies, the disruptions exposed vulnerabilities in its highly efficient, interconnected supply chains.

For example, during the COVID-19 pandemic, reduced API availability due to lockdowns in China pushed up prices of essential drugs by 50 percent,³⁹ highlighting that companies lacked effective derisking strategies.⁴⁰ Geopolitical risks, including trade disputes and conflicts, disrupted global supply chains. Despite these challenges, companies have made only moderate investments to enhance their internal capabilities, structures, and processes to improve their operational resilience.

Recognizing that such discontinuities are challenging to predict, companies could need to prioritize building resilient supply networks.

G. Emerging pockets of geographic nearshoring

Recent global disruptions have encouraged pharma companies to adopt a dual-sourcing model. Previously, the pharma industry predominantly relied on a single-sourcing approach, focusing on cost-effective offshore hubs. In response to heightened demands for resilience and the need to mitigate external disruptions, the industry is now diversifying its supply chains. Companies are integrating hubs closer to their base geographies, thereby shortening value chains and enhancing agility.

³⁹Teena Thacker, "COVID-19 impact: Government panel lists essential drugs that can run out," *Economic Times*, March 3, 2020.

⁴⁰"Taking the pulse of shifting supply chains," McKinsey, August 26, 2022.

This shift is underscored by changing import patterns. For example, pharma imports from Mexico to the United States increased from 4 percent during 2013 to 2019 to 15 percent in 2019 to 2023.⁴¹ Companies could strategically balance responsiveness to customers in these nearer, developed regions while maintaining cost efficiencies in traditional manufacturing centers.

As leading world economies evaluate emerging nearshoring destinations, it will no longer be enough for traditional manufacturing hubs to target unlocking plant or efficiency or cost performance. They might also need to adjust their network strategies to maintain competitiveness.

H. Growth of emerging markets beyond the United States, Europe, and India

Indian pharma companies have traditionally focused on the United States, Europe, and India as the top three value and patient pools to target. Each has large, established healthcare systems, accessible markets, and high demand for generic drugs. For instance, the United States alone has accounted for more than 30 percent of Indian pharma exports for over a decade.⁴²

Emerging markets are now the focus, because of stabilizing growth in developed markets and increasing challenges such as pricing pressures and intensifying competition. This shift has become more pronounced over the past four to six years, and the trend is expected to continue. Pharma sales growth rates in these markets (such as Latin America, the Middle East, and Africa, among others) have consistently outpaced the global average of 7.4 percent in the same period. Since 2023, emerging market growth has increased at nearly twice the global average to 15.1 percent (Exhibit 13).⁴³

⁴¹UN Comtrade Plus, accessed on December 12, 2024.

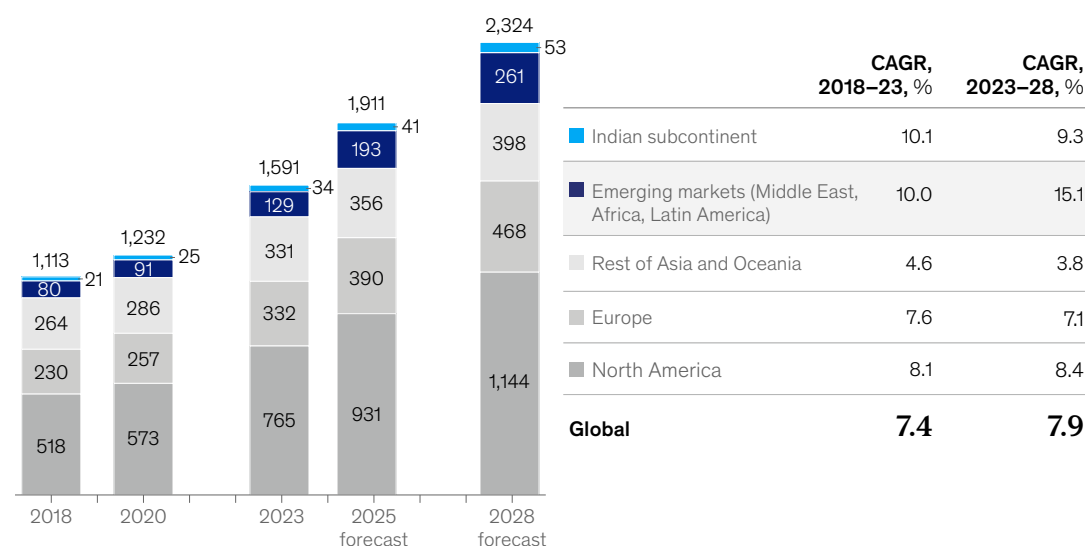
⁴²Trade Statistics, Pharmaceuticals Export Promotion Council of India (Pharmexcil), accessed on November 28, 2024.

⁴³Middle East and Africa: Pharmaceutical market insights, 32nd edition, IQVIA, June 2024.

Exhibit 13

Pharma sales in emerging markets are expected to grow at twice the global average between 2023 and 2028.

Global pharmaceutical sales by region, 2018–28, \$ billion



Source: IQVIA, 2024; MEA Pharmaceutical Market Quality Report, Q1 2024

McKinsey & Company

However, companies do need to address the structural challenges in emerging markets. Indian pharma companies have historically faced significant hurdles in scaling their operations globally. The diverse business landscape, distinct product portfolio requirements, and varying demand patterns require tailored back-end support models in operations. The unique standards and specifications of each country further increase compliance requirements. Infrastructure deficiencies and logistical bottlenecks can complicate efficient distribution. Geopolitical uncertainties also pose significant risks to market entry and operations. As companies address these challenges, Indian players are expected to gain scale over the next five to seven years, capitalizing on the potential of these regions.

I. Environmental sustainability becoming the right to do business

Sustainability has transitioned from corporate responsibility to a business-critical imperative within the pharma industry. Increasing cognizance from diverse stakeholders contributes to this shift:

- **Changing customer expectations and regulations.** Healthcare providers such as the United Kingdom's National Health Service (NHS) are integrating carbon neutrality pledges,⁴⁴ making carbon net zero a requirement for tender offers. In parallel, regulators are introducing stringent requirements, such as the EU's Green Deal and Climate Law that aims to cut emissions by 55 percent by 2030,⁴⁵ alongside its Health Union to address health inequities.
- **Increasing commitment from peers.** Net-zero commitments are gaining traction across industries, with 20 percent of the world's largest public companies committed to net-zero targets.⁴⁶ Within the pharma industry, the number of companies with science-based targets for emission reductions grew from seven to 104 between 2019 and 2022.⁴⁷
- **Investor appetite.** Global investors are increasingly embedding environmental, social, and governance (ESG) criteria in their investment decisions, with ES assets expected to reach \$40 trillion by 2030, accounting for nearly 25 percent of global assets under management.⁴⁸

While many companies have set ambitious sustainability goals, significant reductions require them to address Scope 3 emissions, which constitute approximately 70 percent of the industry's total emissions (Exhibit 14).

A substantial portion of upstream Scope 3 emissions are attributed to the purchase of goods and services, such as fuel, steel components, and packaging. Several of these are fragmented industries with limited emission-tracking transparency. The capital goods sourcing process involves a complex network of vendors and numerous third parties; for example, a typical pharma company might collaborate with over 1,000 suppliers. Similarly, downstream emissions from the use of sold products pose further challenges for decarbonization, such as the need for propellant gases in inhalers.

This fragmented landscape makes it very difficult to tackle Scope 3 emissions. One way to effectively address this challenge is incorporating emission data into all the decision-making processes. Companies could cultivate enhanced connectivity and actively engage stakeholders to manage the most impactful emission sources.

⁴⁴Delivering a 'net zero' National Health Service, NHS England, July 2022.

⁴⁵"The European Green Deal goals and benefits," European Parliament, June 2020.

⁴⁶Deborah Nason, "'Sustainable investing' is surging, accounting for 33% of total U.S. assets under management," CNBC, December 2020; Witold Henisz, Tim Koller, and Robin Nuttall, "Five ways that ESG creates value," *McKinsey Quarterly*, November 2019; *Sustainable Share Index™: Research on IRI purchasing data*, NYU Stern Center for Sustainable Business, March 11, 2019; "Three-quarters of Millennials would take a pay cut to work for a socially responsible company, according to research from Cone Communications," Cone Communications press release, November 2, 2016; Disha Shetty, "A fifth of world's largest companies committed to net zero target," *Forbes*, March 24, 2021; *Taking stock: A global assessment of net zero targets*, Energy and Climate Intelligence Units and University of Oxford, March 23, 2021.

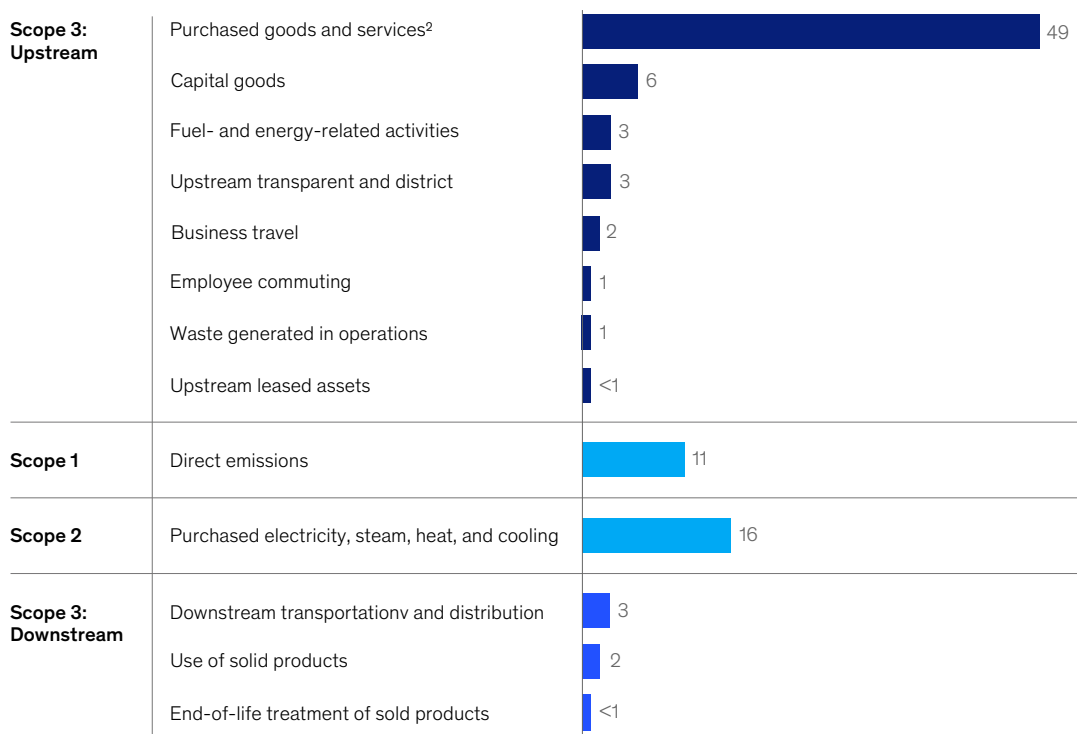
⁴⁷Maria Fernandez and Lucy Pérez, "Accelerating the transition to net zero in life sciences," *McKinsey*, August 11, 2023.

⁴⁸"Global ESG assets predicted to hit \$40 trillion by 2030, despite challenging environment, forecasts Bloomberg Intelligence," Bloomberg Intelligence press release, February 8, 2024.

Exhibit 14

Emission profiles from 38 life sciences companies indicate that over 70 percent of greenhouse gas emissions stem from Scope 3 activities.

Greenhouse gas emissions by source, based on CDP emissions data, normalized by revenue,¹
% of total



Note: Scope 1 and 2 emissions are provided as single totals by CDP. Scope 3 emissions with negligible emissions or sufficient peer data have been omitted.
¹Baselining is made using available data using spend-based data, consumption-based data, activity-based data. Data is automatically ingested from ERP and other business systems.

²Purchased goods category refers to the carbon intensity in raw materials products (eg, APIs, metals, plastics, electronics, packaging) produced by lump sum suppliers.

Source: Catalyst Zero; Company data; CDP

McKinsey & Company

J. Global tailwinds boosting pharma CDMO and services

India's CDMO segment constitutes less than 5 percent of the global CDMO market (estimated at \$144 billion to \$169 billion in 2024). India CDMO revenues—and share of global revenues—surged after 2020, after which growth stabilized in a longer trajectory, expanding capabilities and competitive offerings. The segment is expected to grow at a CAGR of 12 to 14 percent, potentially capturing 8 to 10 percent of global market share by 2033.

Several international and regional tailwinds are propelling this growth:

- **Evolving regulatory and geopolitical shifts.** Pharma companies are reducing their reliance on single-source CDMOs, making India a preferred alternative for Western countries. A McKinsey survey indicates that over 50 percent of executives are considering this transition, with more than 30 percent preferring India as their alternative. Further, the Inflation Reduction Act (IRA) is expected to support simultaneous drug development efforts, thereby boosting clinical supply volumes and accelerating market entry.

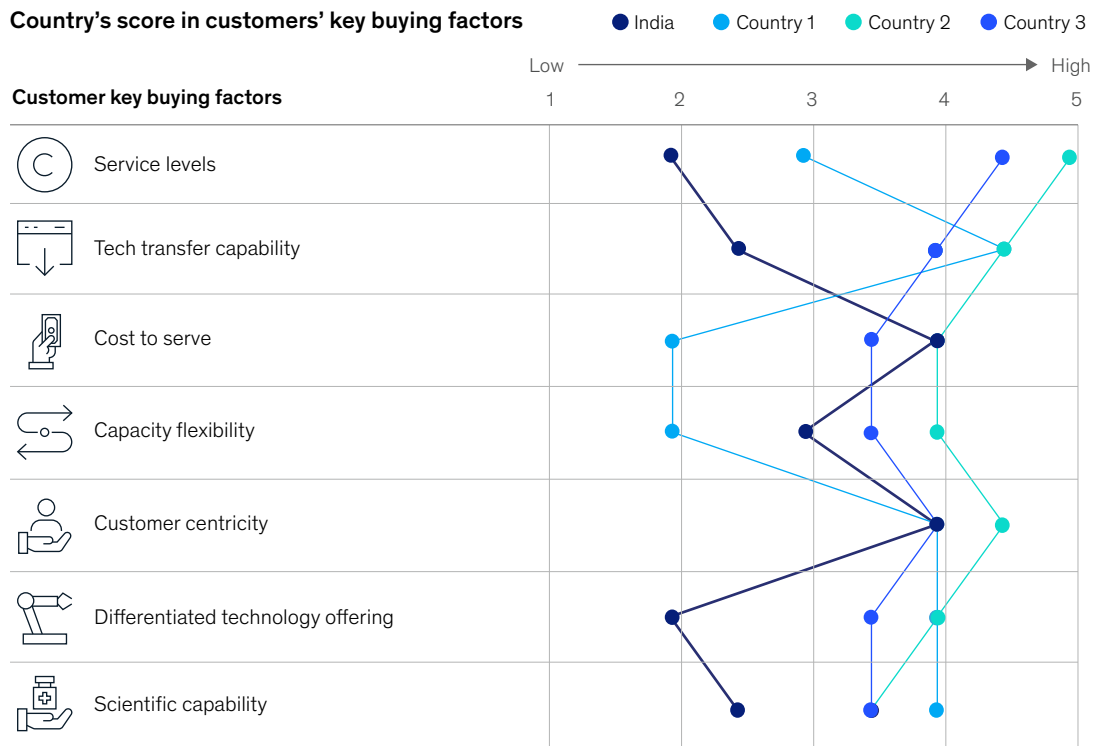
- **Improved capacity and capability of CDMOs.** The landscape for Indian CDMOs is expanding with growing traction from Western innovators due to their specialized capabilities and improved flexibility. There is growing evidence that Indian CDMOs supply APIs and secure contracts in biotech, areas that were not typically outsourced to India a decade ago. Over the past four years, the top five CDMOs in India have invested nearly \$650 million to expand their capacity and augment their capabilities.⁴⁹
- **Continued cost pressure.** Multiple leading pharma and biopharmaceutical companies have already announced improvement efforts to address the potential decrease in margins (for example, 3 to 5 percent decline expected in EBITDA per year for biopharma companies) due to the IRA.⁵⁰ India's location offers economies of scale, making it an attractive choice for companies facing patent expiry. With more talent available, India is increasingly preferred for outsourcing noncore activities.

⁴⁹"Beyond manufacturing: Broadening horizons of CDMOs," Aragen Life Sciences, November 15, 2023.

⁵⁰McKinsey analysis.

Exhibit 15

Indian contract development and manufacturing organizations could focus on seven key dimensions to scale up their capabilities.



Note: Countries 1, 2, and 3 contribute >80% of contract development and manufacturing organizations market share.
Source: McKinsey India LSS Roundtable Survey 2023 (n = 16)

- ***Supportive Indian regulatory ecosystem.*** India's regulatory framework supports manufacturing growth. For example, the PLI scheme offers financial incentives for domestic manufacturing, strengthening India's role in the global landscape.

To capture value effectively, Indian CDMOs could align with their customers' key buying factors. A McKinsey CDMO industry survey indicates that Indian CDMOs often lag other regions on various dimensions (Exhibit 15). To do this successfully, CDMOs will need to think through their operations backbone very differently and plan for greater agility, efficiency, and reliability.

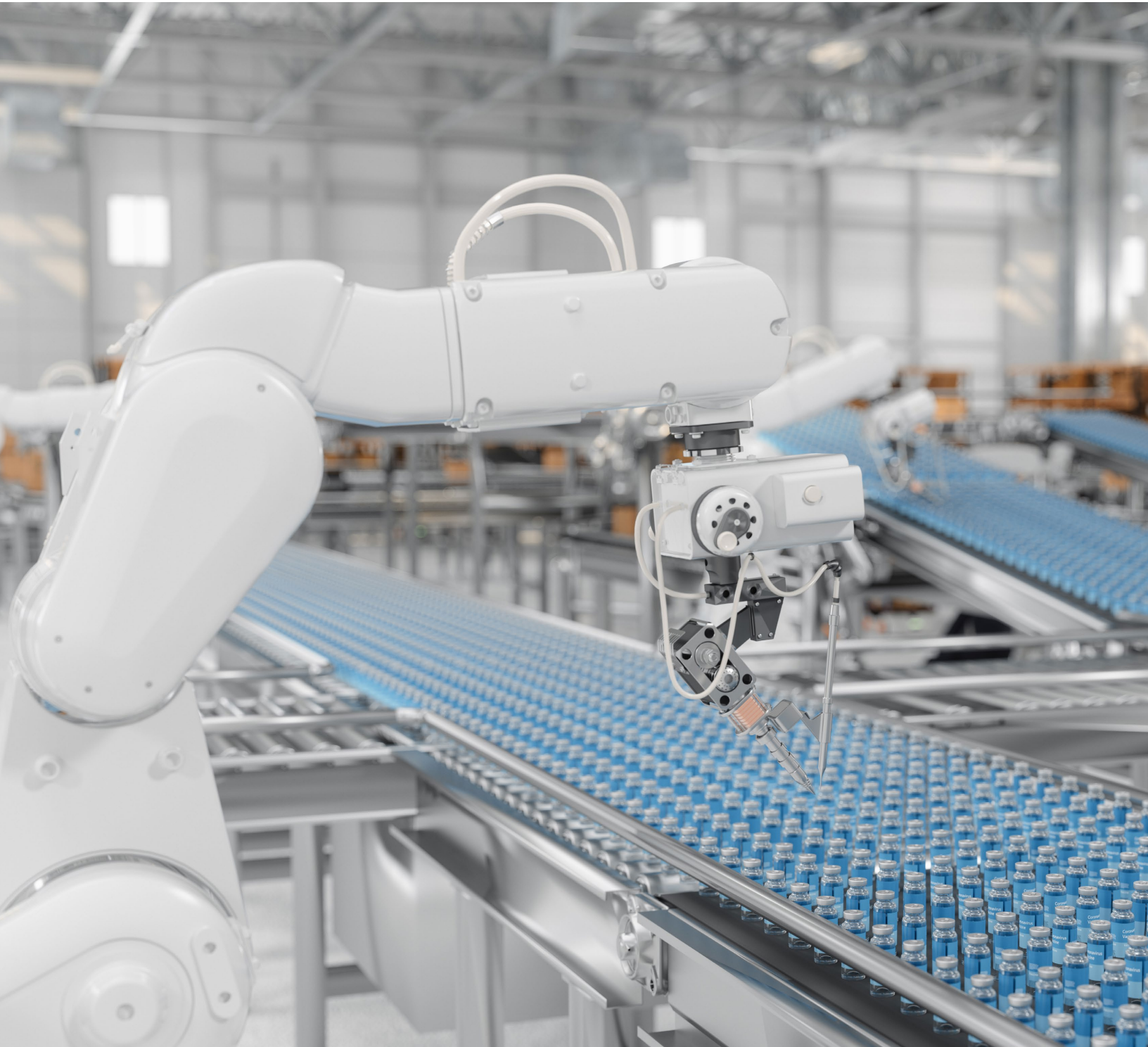


In the next decade, Indian pharma companies will face a dynamic landscape with emerging challenges and opportunities. To keep their lead and align with the industry's vision of being the gold standard for operational efficiency, quality excellence, and cost competitiveness, companies need to reflect on the most necessary capabilities they should develop in the short term and the long term.



CHAPTER 3

Themes for the future of Indian pharmaceutical operations



India's pharmaceutical sector is at a tipping point. Over the next decade, it could redefine its operational strategies with initiatives like zero-error quality systems, sentient and miniaturized manufacturing, expanded cost leadership, autonomous planning, and green network initiatives, emerging as an industry reputed for agile, efficient, reliable, and sustainable operations (Exhibit 16).

A. Zero-error operations enabled by future-shaping smart quality systems

Advanced technologies help companies aim to error-proof day-to-day operations. With such technologies, the industry could shift its approach to quality, from foundational compliance to a holistic focus on operational excellence.

Zero-error operations approaches are widely used in several other industries. Semiconductor manufacturing uses deep analytics to predict and prevent defects ahead of time, while the automotive sector uses integrated technical production systems to enhance reliability, minimize variability, and eliminate waste.

For pharmaceuticals, such an approach could require shifting from reactively resolving issues to proactively preventing defects, and from merely reducing errors to structurally eliminating them. Zero-error operations imply gold-standard outcomes such as over 99.9 percent right first time, less than 0.01 percent batch failures and deviations, eight-sigma process capability, and zero repeat errors.⁵¹ A focus on six areas could help achieve zero-error operations in pharmaceuticals (Exhibit 17).

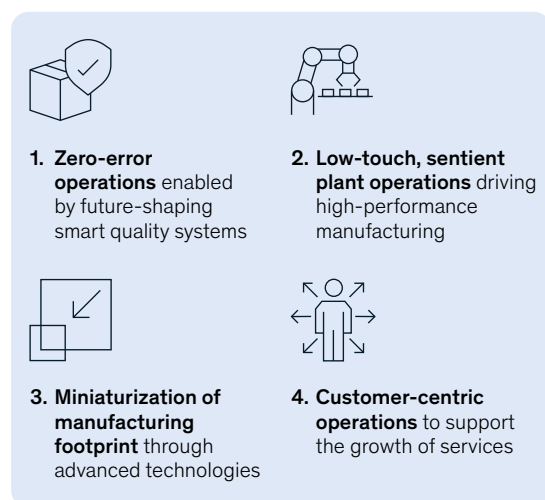
1. **Real-time online product mastery for eight-sigma quality outcomes.** This goes beyond traditional risk assessment techniques such as failure mode and effects analysis (FMEA) and lean golden-batch analytics to deliver data-driven predictive insights on product quality. It can drive real-time

⁵¹McKinsey analysis.

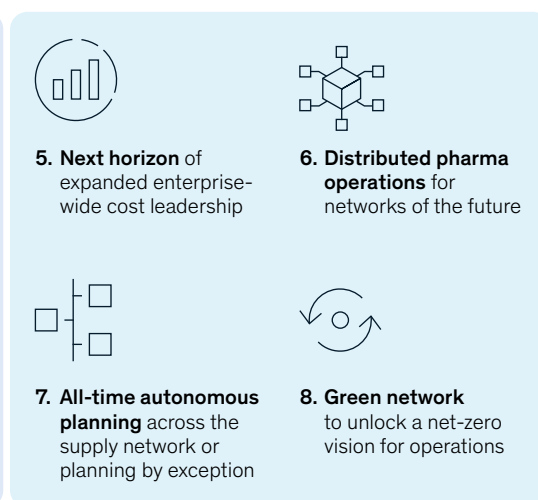
Exhibit 16

Eight priority themes could shape the next decade of pharmaceutical operations.

Plant-level focus areas

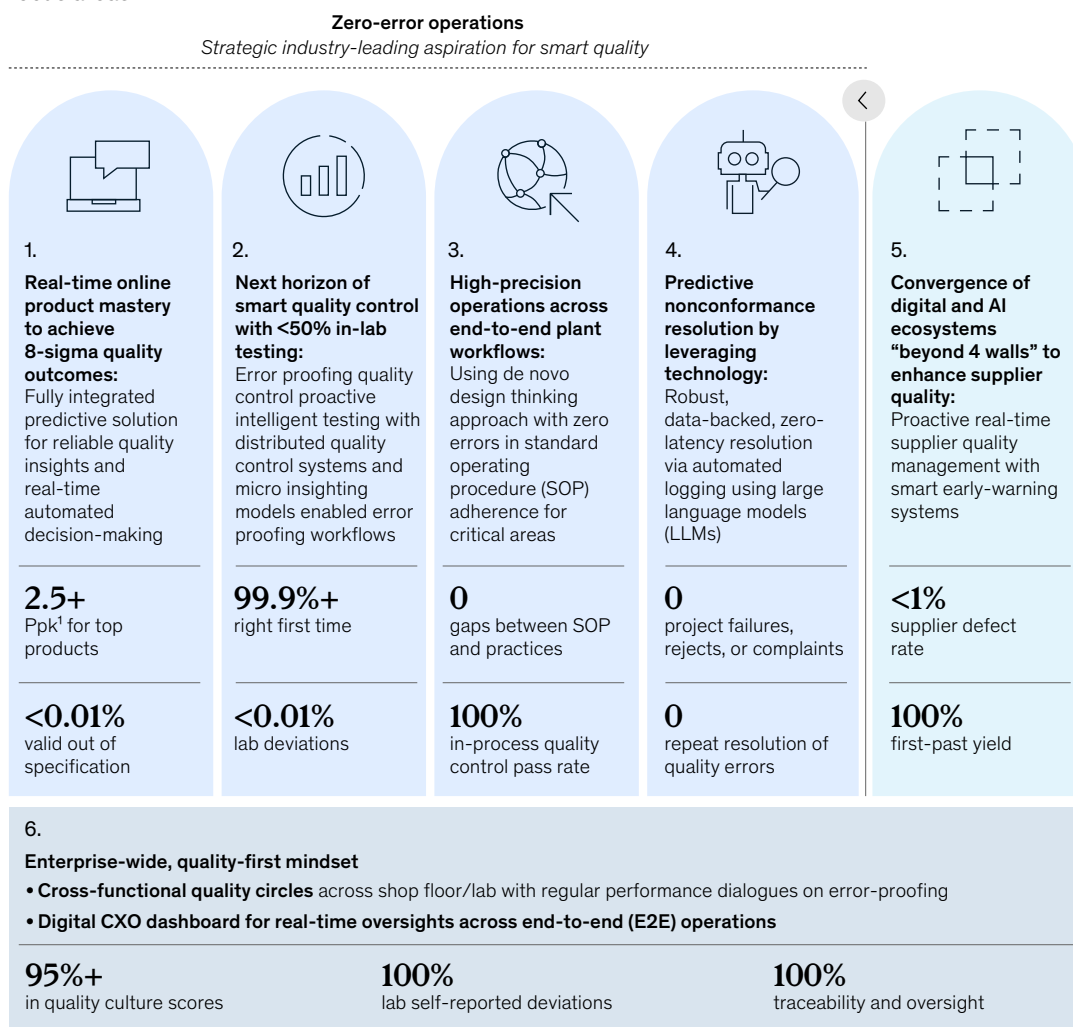


Network-wide priorities



Six focus areas could unlock zero-error operations.

Focus areas



¹Process capability/process performance index.

McKinsey & Company

automated decision-making and ensure end-to-end product and process control. Examples of this approach include:

- **Real-time product quality insights and self-responsive process control.** For instance, online AI/ML models can predict product outcomes at the start of batch manufacturing and, with real-time monitoring, drive AI-led automated process adjustments. An example is automated blending time extension based on live business unit insights.
- **AI-powered early warnings for shop floor executives using online ML engines.** These could prescribe in-time or ahead-of-time corrections, such as calibration notifications for equipment parameter fluctuations.

- **AI-enabled integrated tech transfer process with end-to-end traceability of underlying product and process attributes from R&D to plant operations.** Examples could include clear statistical and scientific linkages between process parameters (for example, temperature, pressure), material attributes (particle size, purity), and product quality attributes (efficacy, stability).
2. **Next horizon of smart quality control with less than 50 percent in-lab testing.** This involves fundamentally transforming lab testing from a reactive safeguard to a proactive real-time testing system that can completely streamline testing workflows in plant operations. Some examples:
- **Distributed quality control.** Implement decentralized, real-time, and autonomous testing on the shop floor, using a combination of quality-testing automation and AI and ML platforms to eliminate the need for lab-based testing. This could involve real-time release testing with process analytical technology (PAT), instantaneous microbial detection on the shop floor through real-time airborne particle counters, among other applications.
 - **Error-proofing testing and nontesting workflows.** Deploy “micro-insighting” models to detect lab anomalies and identify underlying root causes. Employ digital or AI assistants to automate redundant lab reviews and decision-making. Minimize human dependence through smart lab automation such as end-to-end integrated assay automation, automated sample preparation, and real-time smoke studies through equipment sensors and online environmental monitoring systems.
3. **High-precision operations across end-to-end plant workflows.** With such workflows, intelligent process development, process revision, and advanced automation could ensure 100 percent compliance and execution. Some examples:
- **Tech-enablement to streamline SOP design.** A user-backed design-thinking approach to standard operating procedure (SOP) design, in combination with large language models (LLM) or generative AI, could surface error-prone sections, procedural redundancies, and vague areas in SOPs. This will help to ensure all procedures remain user-friendly, error-proof, and fully compliant with the latest standards.
 - **Zero errors in SOP adherence for targeted areas.** Interactive digital delivery of SOPs or work instructions on production systems or real-time wearables, coupled with AI-powered anomaly detection systems, could monitor all-time adherence.
 - **Proactive SOP revision.** Analysis of regulatory guidelines via digital or AI, online equipment, and area monitoring can be used to surface potential SOP obsolescence ahead of time.
4. **Predictive nonconformance resolution.** Leveraging technology for a robust, data-backed, and efficient investigation-to-resolution process can drive rapid no-repeat resolution of quality errors. Some examples:
- **Real-time automated incident or deviation logging to create 100 percent traceability and oversight.** This could take the form of tech-enabled continuous monitoring of process parameters, environmental conditions, and equipment performance.
 - **Gen-AI-powered investigations assistants.** LLMs could be used to generate consistent high-quality investigations with clear language, logical flow, and structure that are compliant with internal and external standards.
 - **Data-driven root-cause analysis.** AI, ML, and gen AI can be employed to identify root causes and CAPAs, leveraging scientific correlation and public knowledge, including guidelines, white papers, and inputs from small and medium-size enterprises.

5. **Convergence of digital and AI ecosystems beyond four walls for less than 1 percent supplier defects.**

Set up systems for autonomous, real-time quality assurance across the supplier ecosystem. Companies can proactively manage input material quality by using granular data for real-time insights into supplier quality performance. They can supplement this with AI/ML systems for early warning signals. The main components of such an approach could include the following:

- **Dynamic supplier risk assessment.** A holistic approach considers both internal and external factors. Externally, it measures supplier exposure to factors such as compliance outcomes, regulatory findings, and organizational reputation. This can be contrasted against insights from available internal data such as critical material attributes or material trends.
- **Granular supply network assessment.** Sub-tier supply networks can be mapped to understand deep supply chain risks. This can be done by integrating public and proprietary data sets to identify tier-n dependencies and prioritize suppliers based on factors such as centrality to network underlying vulnerabilities and business importance.
- **Proactive digital supplier quality management.** Smart early-warning systems can be deployed to flag and address supplier quality issues in real time through automated alerts and targeted notifications.

6. **Enterprise-wide quality-first mindset.** Prioritize a culture of patient safety and zero defects in day-to-day operations. Adopt a holistic approach to quality culture, focusing on behavioral and mindset shifts. Examples include building proactive quality ownership across levels and functions, leveraging AI-driven personalized learning platforms for continuous quality education, and using hyperconnected real-time dashboards to enable collaboration for seamless quality management.

Implementing such a zero-error approach can yield substantial benefits. While it may require pharma companies to revisit their ways of working, error-proofing end-to-end operations could usher in a new paradigm of quality leadership for the industry. Organizations could take a cycle-wide view of automation investments instead of seeking short-term ROI. It could also be important to grow fundamental plant capabilities from understanding product chemistries to overseeing equipment, acting on micro-analytics-driven insights, and making data-driven decisions.

B. Low-touch, sentient plant operations driving high-performance manufacturing

Low-touch, sentient plant operations are an advanced production process where intelligent systems autonomously manage and optimize manufacturing operations with minimal human intervention.

Leaders across industries are already starting to reimagine their operations. Leading electronics manufacturers have automated 75 percent of production and developed gen-AI-based self-learning systems for continuous performance enhancement.⁵² Semiconductor companies have implemented intelligent manufacturing systems that not only improve performance but also reduce human interactions by 80 percent through self-learning.⁵³

The overall impact of such sentient manufacturing systems can be transformative. Not only could they bring about a repeatable step change in efficiencies—such as manufacturing cost reductions of more than 40 percent, overall equipment effectiveness (OEE) consistently exceeding 70 percent, a doubling of productivity,⁵⁴ and plant downtimes reduced by 70 percent⁵⁵—they also could eliminate human error and enhance overall product quality.

⁵²*Discussion with Siemens: A blueprint for factory digitalization and a more sustainable future," Capgemini, November 22, 2021.

⁵³Expert interview.

⁵⁴*Generative AI in the pharmaceutical industry: Moving from hype to reality," McKinsey, January 9, 2024.

⁵⁵*Transforming advanced manufacturing through Industry 4.0," McKinsey, June 27, 2022.

Achieving low-touch, sentient manufacturing operations could look like the model in Exhibit 18. Achieving this will require a focus on three levers:

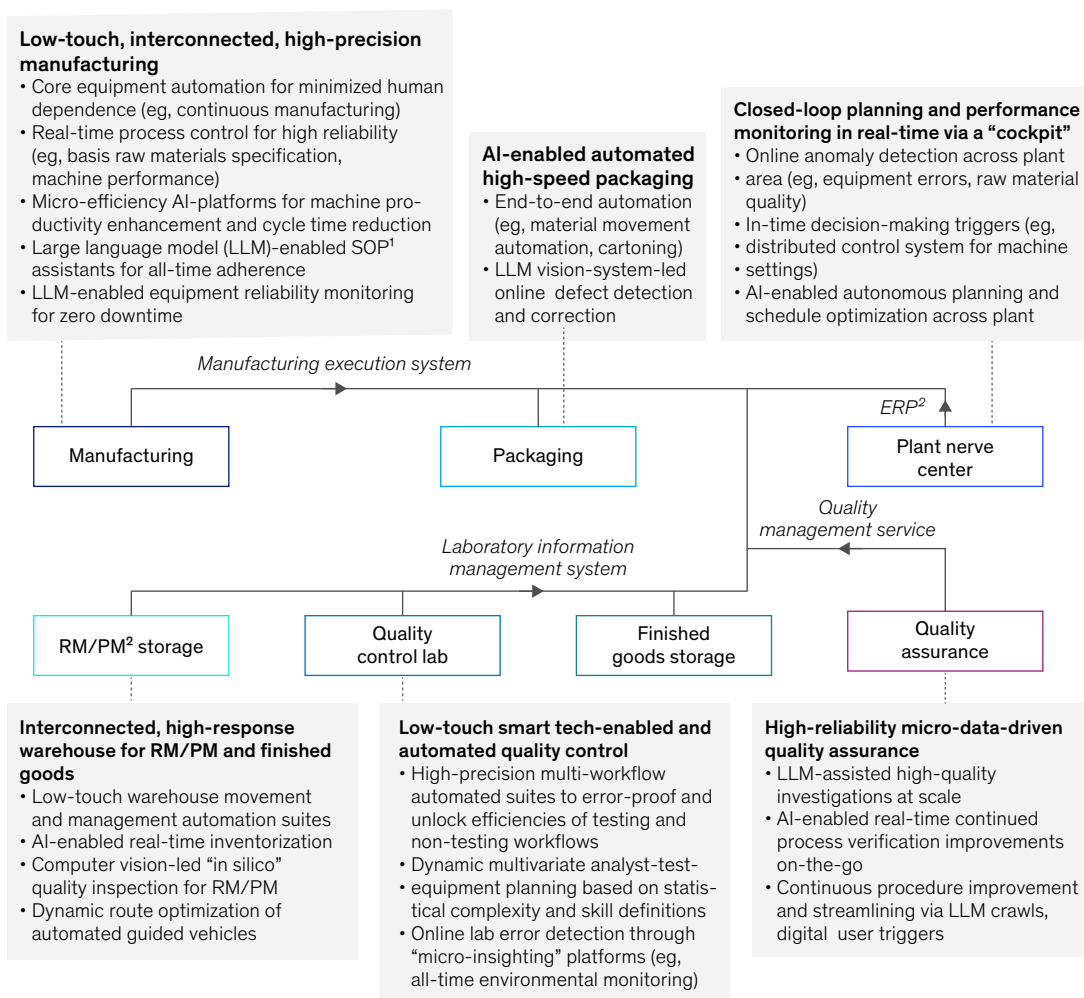
1. **Core operations technology upgrades.** Upgrade core lab and shop floor equipment that directly interacts with products to enhance interconnectivity, automation, and performance. This would mean deploying equipment such as roll compactors for granulation, PAT tools for online testing, and interface detection probes for automated layer separation. These can be integrated with intelligent recipe-based control systems.

Developing seamless low-touch workflows can reduce reliance on manual judgement and interventions, boosting efficiency and reliability in core operations.

Exhibit 18

Low-touch, sentient plant operations could drive high-performance manufacturing.

Illustrative production process



¹Standard operating procedure.

²Enterprise resource planning.

³Raw materials/packing materials.

2. **Smart automation of manual processes.** Ancillary activities such as material handling and transport, sample preparation, cleaning, and documentation can significantly affect variability and efficiency. However, smart automation solutions are beginning to introduce new, efficient, low-touch ways of working.

Deploying automated guided vehicles (AGVs), robotics, and tech-controlled setups, such as chute-and-conveyors, automated valves, metered pumps, and robotic feeders, could streamline material-handling workflows. New-age automation, such as probes integrated with data acquisition systems and lean robotics, helps companies reimagine traditional high-involvement cleaning processes. Automated sample preparation workbenches and integrated assay automation trains can be embedded into end-to-end lab tech-and-data workflows. Furthermore, there is a thrust on integrating robotic process automation at a sitewide level to eliminate data transcription.⁵⁶

By automating these ancillary processes, companies could significantly reduce plant turnaround times and unlock industry-leading efficiency and reliability.

3. **Digital enablement of workforce.** Beyond core and ancillary automation, advanced tools such as digital solutions, AI, and gen AI could further support and enhance human decision-making.

Integrating data platforms at scale, such as product and test review automation systems, real-time SOP assistants, compliance engines, and LLM-enabled automated investigations, could significantly improve productivity and quality for manufacturers. Leveraging AI and ML at the platform level, such as for guiding machine-setting prescriptions, could enable smarter decision-making and operational excellence, even in areas where full automation is not feasible. Systems like bar-code-based solutions, enterprise resource planning (ERP) systems, and data acquisition systems, such as supervisory control and data acquisition (SCADA), enable continuous monitoring, which improves efficiency and oversight.

To unlock the transformative potential of low-touch, sentient manufacturing, companies must first develop a clear and comprehensive vision of the desired end state. They can then evaluate and prioritize automation opportunities based on their ROI. Continuous performance monitoring and iterative improvements could be crucial to maintaining and enhancing the efficacy of these automated systems.

C. Miniaturization of manufacturing through advanced technologies

Beyond the shift to interconnected sentient operations, factories of the future will also become increasingly modular and miniaturized. Core technology disruptions such as continuous manufacturing, modular “plant-in-plant” setups, and small-scale operation or microreactors for higher reliability, especially in biopharma manufacturing, could reshape plant operations paradigms.

1. **Continuous manufacturing (CM).** Globally, companies are starting to leverage advanced flow chemistry technologies to drive seamless, high-speed production with a significantly smaller footprint than traditional batch processing across API and formulations.
 - **API production.** Continuous-flow reactors and microreactors can deliver precise control over reaction conditions, enhanced yields with little to no variability, and a minimal conversion cost footprint.
 - **Formulation.** High-capacity flow equipment such as roll compactors, continuous blenders, and microencapsulation can support large production volumes with greater process control and a lower footprint for energy and human capital.

As CM has become more widely adopted, regulatory acceptance has increased: As of 2024, the FDA has approved more than 14 CM-manufactured products across oral solids, API, and biopharmaceuticals.⁵⁷ Several companies globally and in India have invested in developing continuous manufacturing lines.

⁵⁶Expert interview.

⁵⁷Kelley Burrige, “Barriers to the development of continuous manufacturing and ICH Q13 (PDA/FDA Joint Regulatory Conference 2023),” BioPharm International, September 18, 2023.

2. **Plant-in-plant (PIP) setups.** PIP entails establishing smaller, specialized production units within a larger manufacturing facility, each with dedicated resourcing and separate operations workflows. Such setups cater to low-volume, high-value production runs without disrupting the operational cadence of primary high-volume production lines.

This modular approach allows organizations to boost multimarket delivery performance while maintaining overall plant efficiencies. It also reduces compliance complexity and mitigates the need for new infrastructure investments, as existing facilities can be retrofitted with specialized units.

This cannot, however, be done at scale across the network. While PIP reduces multimarket complexity, it loses the aggregation synergies of manufacturing the same or similar drugs for different markets in an integrated factory.

Early adopters of PIP in generics pharma have done this for select parts of their operations network, such as producing niche rare-disease drugs or specialty biologics and dedicating factories to serving fragmented emerging markets.

3. **Small-scale operations in biopharma.** Specifically, in biopharma operations, there is a gradual shift to flow reactors and microreactors, which can optimize chemical reactions on a miniaturized scale and provide enhanced precision in controlling reaction conditions to improve product quality.⁵⁸

Such setups could not only produce high volumes with greater process control but also reduce reagent and solvent usage and minimize waste. This makes them ideal for scaling up complex processes without compromising efficiency or safety. While still nascent, this approach is being adopted by organizations for niche drug products, such as cytotoxic or high-potency products, due to the added benefits of close confinement of hazardous reactions.

While early adoption of CM, PIP, and small-scale biopharma operations has started, a few structural challenges are likely to limit at-scale adoption across entire networks:

- slow pace of regulatory acceptance for disruptions in core manufacturing technologies, such as on CM and microreaction in biopharma
- limitations on the nature of products and business segments where this applies—for example, large-volume “runner products” (products in high demand, produced more frequently) for CM, niche or specialty products for PIP setups
- drastic changes in plant operating models, such as the adoption of 24/7 manufacturing for CM, flexible operations workflows for PIP
- high requirement of advanced technical skills, such as expertise in new technology handling for CM, process optimization for PIP and small-scale operations setups

In the face of such challenges, companies have opted for partially miniaturized setups to deliver some performance improvements while not being as constrained as end-to-end setups. For example, they are deploying specific CM equipment in targeted areas instead of plantwide, establishing PIP setups only for niche portfolios and emerging-market businesses.

In this context, as the industry heralds a new era of manufacturing innovation through miniaturization, 20 to 30 percent of global operations capacities are expected to make this transition.

⁵⁸Expert interview.

D. Customer-centric operations to support services growth

The evolving geopolitical landscape presents considerable potential for CDMOs and pharma services. Indian companies, however, could further strengthen their competitive positioning on the global landscape of pharma services.

Organizations could unlock these opportunities in the medium to long term by pursuing five priorities:

1. ***Broaden offerings portfolio.*** Develop the next set of capabilities to widen the portfolio beyond traditional small molecules in biologics drug substance, chemical API, and drug products. Strategic investments in advanced manufacturing technologies, such as prefilled syringes and production cell lines, could be crucial for offering enhanced services and pursuing competitive differentiation.
2. ***Cultivate a customer-centric operations excellence model.*** In the CDMO space, operational excellence is key to differentiating with pharma and biotech clients. Indian CDMOs likely will need to prioritize customer-centric capabilities such as a streamlined and robust tech transfer, efficient project management, enhanced value chain visibility, and a collaborative, cross-silo approach to day-to-day operations for success.
3. ***Streamline operations for agility and efficiency.*** Improved delivery timelines and reduced turnaround time are essential to maintain competitive costs and delivery. Streamlining procurement and supply chain processes to reduce raw-material lead times from two to four weeks to two to three days may expedite project delivery. Leveraging India's cost advantages, such as labor and manufacturing costs below those of Western counterparts, CDMOs could sustain a 30 to 40 percent edge on efficiency.⁵⁹
4. ***Attract and retain top talent.*** It is also important to build and retain a highly skilled workforce across project management and operational functions. Investing in talent from top-tier universities and attracting senior Indian-origin expatriates with niche expertise could strengthen capabilities in complex modalities. Simultaneously, upskilling existing employees could enhance operational efficiency and enable leadership in advanced projects.
5. ***Continue focusing on capacity expansion.*** Meeting rising demand and embracing new modalities requires sustained investments in manufacturing capacity. CDMOs could look out for initiatives (even with delayed ROI) to secure long-term growth and competitiveness, positioning themselves as reliable partners for global pharma companies.

Doing this successfully could help position Indian CDMOs as driving innovation and bolstering operational resilience, cementing their leadership on the global stage.

E. Distributed pharma operations: Networks of the future

Given the scale of disruptions the industry is going through, such as supply shortages, geopolitical uncertainties, and increased proliferation of complex modalities, leading companies could benefit from rethinking their operations strategies to maintain competitiveness and resilience.

Two trends could shape the manufacturing networks of the future:

1. ***Emergence of centers of excellence (COEs).*** As companies navigate the increasing complexity of global pipelines, they should consider enhancing capabilities, adopting intricate plant operating models, and developing innovative cross-functional linkages. Setting up COEs that serve as hubs for innovation and specialized knowledge and drive advancements in drug development and manufacturing could help them sustain such continuous improvement. These COEs could require a fundamentally different setup across the network and the plant operating model:

⁵⁹Assessment of Indian pharmaceutical and CDMO market, CRISIL, October 2023.

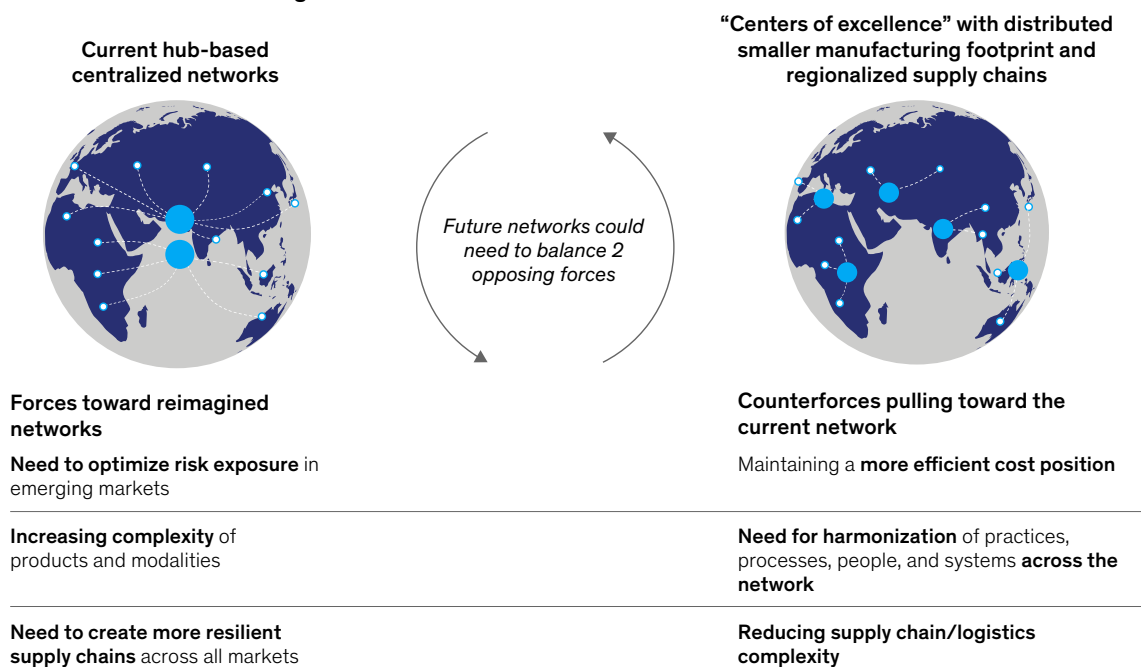
- an integrated operating model connecting R&D and operations (for example, clubbing research and manufacturing to facilitate seamless knowledge transfer and optimize production processes)
 - a systematic approach to building specialized talent that includes ahead-of-time investment, repatriation of scientific talent, and cross-geography deployment strategies
 - building digitally integrated operations infrastructure to support seamless collaboration and process optimization
2. ***Distributed manufacturing footprints and regionalization.*** With the growth of emerging markets as future value pools and the potential emergence of specialized COEs, companies could transition part of their production from large, high-capacity plants to smaller, more distributed sites to build more resilient supply chains. Such regionalization could support agile and localized production and, in turn, enable better material availability, faster distribution, and shorter lead times. However, the high costs associated with making (and maintaining) such changes may be prohibitive for entire networks to do this at scale.

These two trends could significantly disrupt operational strategies and shape future networks. However, given the emphasis on near-term cost efficiencies, challenges in harmonizing an already-complex plant operating model, and management of supply chain and logistics operations, companies are likely to adopt a balanced approach in their networks. Organizations might regionalize only targeted parts of downstream operations rather than implement drastic changes across entire networks. Distributed networks of the future could therefore evolve based on company-specific calls depending on the spread of individual portfolios across technologies and geographies (Exhibit 19).

Exhibit 19

Multiple forces are driving pharmaceutical companies to reimagine their network strategies.

Illustrative network strategies



F. All-time autonomous planning across the supply network: 'Planning by exception'

Transitioning to a hands-free planning approach could improve supply chain performance and long-term resilience. Companies could make the transition by automating manual interventions, hardwiring data-based decision-making into everyday operations, and building structural supply security.

Industries including consumer goods, automotive, and electronics have progressed in implementing such hands-free planning approaches. Fast-moving consumer goods (FMCG) companies are investing in setting up end-to-end automated planning processes—from demand to supply, inventory, and dispatch—to unlock over 99 percent of industry-leading service levels with more than 30 percent lower inventory.⁶⁰ Consumer electronics companies are successfully adopting fully autonomous planning processes,⁶¹ such as autonomous demand forecasting to minimize overproduction and stockouts, enabled by a suite of ML algorithms, real-time production scheduling with deep capacity simulation tools, and AI-enabled advanced scenario planning.

Such approaches also have high potential in pharmaceuticals and could improve service across the network and unlock new performance levels—for example, 30 percent reductions in planning and inventory costs⁶² and 25 to 40 reductions in lead times.⁶³ It can also make networks more resilient to unforeseen disruptions.

Global pharma companies have started to integrate autonomous planning principles into their supply chains through interventions such as AI/ML-led approaches to demand forecasting, AI-powered demand-supply-inventory-logistics-fulfillment cycles, dynamic near-real-time production scheduling, real-time scientific inventory management, and risk management based on early-warning systems.⁶⁴ These could enhance planning efficiencies, reduce supply chain costs, and improve planning responsiveness.

However, achieving autonomous planning is a longer journey for pharma leaders. They need to carefully consider and consistently implement three important elements:

- ***Ensure a low-/no-touch approach through integrated digital and AI deployment across the end-to-end planning cycle.*** This strategy involves carefully mapping end-to-end planning workflows and embedding digital as well as AI applications at different stages to enhance accuracy, reliability, and the consistency of decision-making while also streamlining planning cycles. For instance, AI-driven advanced statistical demand forecasting could enable a relatively accurate, automatic prediction of demand outlook. Advanced ML algorithms could optimize inventory levels by dynamically adjusting stock norms based on real-time data. Supply-chain digital twins can simulate different production scenarios and potentially enable proactive adjustments to manufacturing processes to meet changing demands.
- ***Reimagine the current operating model and talent strategies to embed new ways of working.*** When companies deploy low-/no-touch planning applications, the nature of work will evolve. For example, the focus of human roles in planning could shift from routine planning tasks to managing exceptions and ensuring data reliability. Organizations would need to redesign key processes and replace traditional planning cycles with more adaptive setups, calling for a new talent strategy and operating model that embeds new roles for data, digital, and expertise in traditional planning and scheduling functions.
- ***Deploy a future-proof APS and data backbone to support and sustain autonomous planning.*** To extract the potential of autonomous planning, companies need to integrate all digital and AI tools into a single advanced planning system (APS) backbone and drive at-scale adoption across the entire network. Such integrations could hardwire new technology-enabled autonomous planning cycles.

⁶⁰ Jérémie Ghandour, Tim Lange, Andreas Seyfert, and Alessandro Turco, "Consumer goods companies must transform their planning end-to-end," McKinsey, November 24, 2021.

⁶¹ Expert interview.

⁶² Jérémie Ghandour, Tim Lange, Andreas Seyfert, and Alessandro Turco, "Consumer goods companies must transform their planning end-to-end," McKinsey, November 24, 2021.

⁶³ "Generative AI in the pharmaceutical industry: Moving from hype to reality," McKinsey, January 9, 2024.

⁶⁴ Expert interview.

To support the APS, companies could also establish a reliable data governance practice across the organization. For example, setting up a master data management system with clear accountability, objective data quality metrics, proactive data audits, and transparent approval workflows.

In a recent McKinsey survey of failed APS deployments, respondents identified a combination of process, data, and configuration gaps and insufficient change management as the primary contributing factors for failure. The factors included technical gaps, such as misalignment between practical operations and algorithms, erroneous master data, and vague role definitions in APS-driven planning, as well as organizational change gaps, such as minimal incentives for APS uptake, skill deficiencies, and overlooked business needs (Exhibit 20).

Successful APS implementers invest two to six times more than unsuccessful APS implementers in building capabilities that simulate real-life scenarios with APS, master data management, analytics for inventory management, and systematic root cause analyses.⁶⁵

The deployment of autonomous planning is likelier when companies shift from their current, people-intensive working methods to drive substantial process improvement, bold business-backed technology enablement, and organization-wide adoption of new hands-free planning approaches. Through this, early adopters have been able to automate low-risk decision-making on supplies and drastically reduce reaction times across the supply chain. Early adopters are also able to operate at much higher efficiency levels and build a more transparent and responsive supply chain.

G. Next horizon of expanded enterprise-wide cost leadership

As traditional approaches to efficiency and productivity performance start running out and results start to plateau, pharma companies need to unlock the next S-curve of performance in operations.

Recent technology disruptions have surfaced several avenues that India could follow to take its cost excellence to new levels. These consist of four main focus areas (Exhibit 21):

1. **Attaining cost leadership in large molecules.** In small molecules, India has reduced manufacturing cost by 30 to 35 percent compared with its global peers, and a similar leadership approach now needs to be deployed to large molecules or biologics or biosimilars, where India operates at a cost advantage of less than 20 percent. New technologies, such as AI-based deep-learning platforms, in silico reaction simulation tools, and dynamic planning engines, could play an important role in aiding organizations on this journey.

Pharma companies not only could boost outcomes on core plant efficiencies (such as less than ten percentage points downstream yield and upstream titer variability, below 15 percentage points variability in cycle times, top-decile plant cost or cost per gram), but also usher in a new age of procurement and sourcing excellence (over 60 percent of critical materials being dual sourced, top-decile responsiveness to market opportunities, and over 50 percent anticipation of price fluctuations).

2. **Exploring deep de novo scientific optimization for API/KSM manufacturing.** Exploring de novo scientific optimization could involve fundamentally relooking at core scientific cost drivers for API and intermediates for deeper process engineering assessment and value extraction. For example, benchmarking each driver of cost (such as route of synthesis, number of processing steps, choice of reagents, solvents, molar yields, and mass balance) to surface levers for optimization (such as yield improvement, forward or backward integration, change in route of synthesis, and solvent recovery).

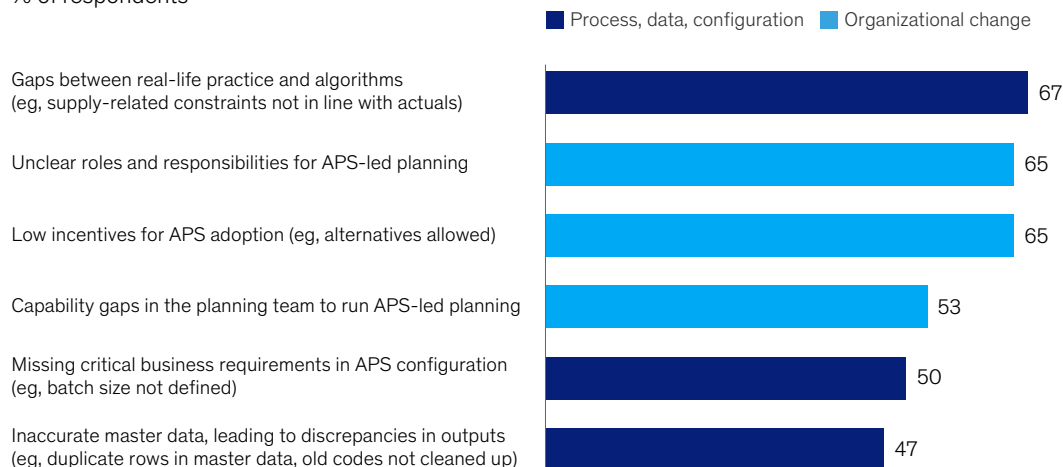
⁶⁵McKinsey Plan4Value Survey, 2024 (n = 55).

Exhibit 20

Process and data gaps, technology, and change management have been the key issues when APS implementation does not deliver value.

Factors companies fail to address that could improve APS¹ success,²

% of respondents



¹Advanced planning and scheduling.

²Question: What did the company fail to address, that could have improved APS success?

Source: McKinsey Plan4Value Survey 2024 (n = 55)

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Organizations have also started to use newer technologies to do this more effectively. For example, they are using gen AI to analyze vast databases of chemical reactions to generate efficient, novel, and scalable synthesis routes. They can do this in one of two ways: retrosynthetic analysis (backward working) of a target API/KSM to propose multiple synthetic pathways ranked by efficiency, cost, yield, and so on, or reaction prediction and condition optimization (forward working) of likely reaction products, and hence, optimized conditions (for example, solvent, catalyst, temperature) for maximum yield or lowest cost.

Successful adopters have achieved cost improvements of up to 20 percentage points on their API business through such approaches.

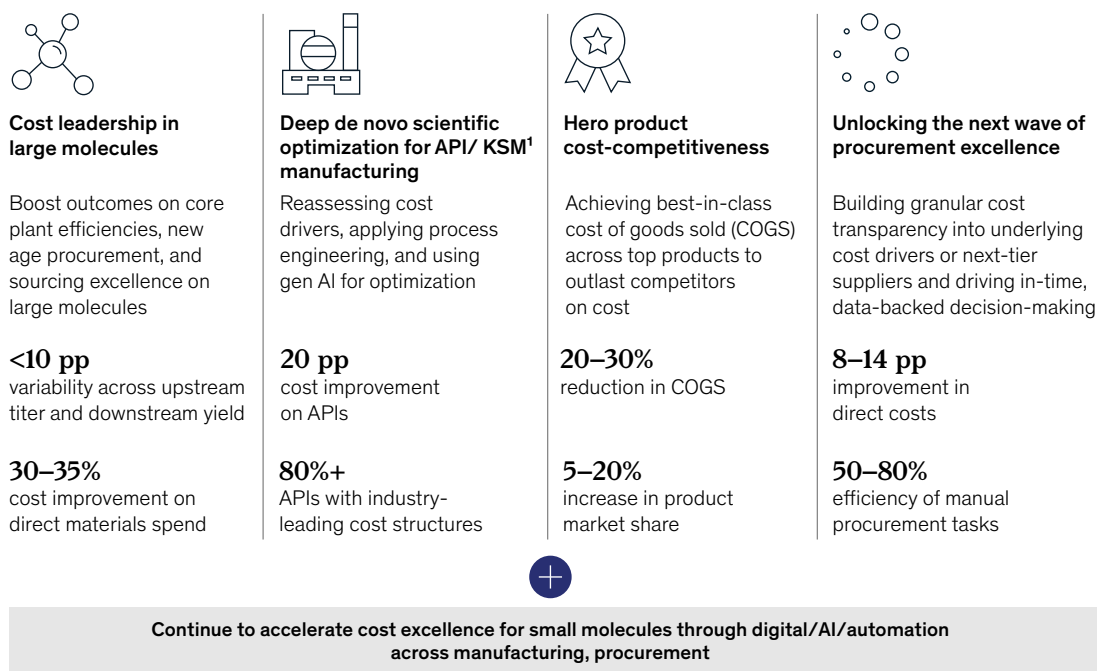
3. **Deploying a hero product cost-competitiveness approach.** The big focus of deploying hero products is for companies to strive for best-in-class cost of goods sold (COGS) for top products so they can outlast competitors on cost (with a last-person-standing market position). A zero-based cost approach is used to holistically assess an exhaustive set of opportunities across APIs, excipients, packaging, and conversion costs and packing charges.

To do this, successful adopters have typically leveraged a combination of benchmarking assessment, strategic moves (for example, negotiations, partnerships), and digital, AI, or ML technologies (for example, spend and category analytics, advanced analytics-enabled golden batch parameters). This approach has allowed players to eliminate almost 20 to 40 percent from anticipated direct material costs of new developments and to reduce overhead costs by over 20 percent.⁶⁶

⁶⁶McKinsey analysis.

Four big areas could drive the S-curve in cost leadership.

Cost leadership considerations



¹Active pharmaceutical ingredient/key starting material.

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4. **Releasing the next wave of procurement excellence.** With the rapid evolution of digital technologies, AI, and gen AI, pharma companies now have a unique opportunity to release the next wave of procurement efficiencies. Players not only can build granular cost transparency into underlying cost drivers or next-tier suppliers and drive in-time, data-backed decision-making, but also can automate transactional activities to retain the major focus on strategic procurement.

For instance, applications such as real-time “input cost monitoring” track the market movement of underlying cost drivers to trigger ahead-of-time purchasing decisions. AI-powered “should cost” modeling allows automated and granular analyses of supplier trends to build cost predictions on key spend items. Early adopters of such approaches are starting to see significant benefits: improvements of 8 to 14 percent in direct costs and 50 to 80 percent in efficiency of manual procurement tasks.

H. Green network: A net-zero vision for operations

While companies have made significant progress in reducing Scope 1 and 2 emissions in recent years,⁶⁷ there is a long way to go in addressing Scope 3 emissions effectively. Several organizations are now setting ambitious goals for themselves, with ten of the top 20 pharmaceutical companies having already declared plans to slash total emissions by over 30 percent by 2030.⁶⁸

However, this journey is not straightforward. Industry leaders are beginning to adopt an integrated “dual mission” approach to optimize costs across spend items and to optimize the Scope 3 footprint in parallel. This is possible given several areas of overlap in both efforts (for example, discussions with the same vendors to create transparency on cost and Scope 3 footprint, win–win ideas to drive cost, and carbon dioxide reduction for vendors). While industries like automotives have already adopted this approach, it is yet to be commonly seen in pharmaceuticals. Five levers could help pharma companies to do this (Exhibit 22).

1. **Raw-material value chain decarbonization.** Decarbonizing the raw-material value chain involves analyzing the cost and carbon footprint of products and components in detail (through teardowns and competitive benchmarking of recipes) to identify actionable solutions for an optimized product design with a 20 to 25 percent smaller carbon footprint.⁶⁹ Specifically in the case of APIs, this also takes the form of green chemistry geared to designing chemical products and processes that eliminate hazardous substances, such as using alternative solvents (for example, biosolvents).
2. **Process and energy efficiency.** Energy efficiency measures and optimization of energy sourcing are crucial for reducing carbon emissions. Companies are doing this in multiple ways, such as using renewable energy sources, improving energy management practices and driving process efficiency improvements beyond solvents. This has cut 30 to 40 percent of process- and energy-related emissions and, through that, reduced energy costs by up to 20 percent.⁷⁰
3. **Recycling and circulating.** This typically involves increasing recycled content in packaging materials and extending overall product lifetimes. For instance, an automotive manufacturer set up closed-loop recycling flows to reuse scrapped parts, reducing both material costs and carbon emissions.
4. **Package and product redesign.** Redesigning packaging to reduce material use is an effective sustainability strategy. This approach can also lead to efficient packaging design that saves costs and materials, such as by eliminating disposable plastics and simplifying the packaging process.
5. **Sustainable supply collaboration.** Organizations collaborating across a broad-based and fragmented ecosystem of suppliers could consider three significant shifts:
 - **Creating end-to-end transparency.** Achieving transparency into carbon emissions across all aspects of the value chain, including subcomponents and materials, requires leveraging unstructured data from various sources and tapping into emission libraries to build a fact base for each supplier.
 - **Building strategic partnerships.** It is critical to form partnerships with suppliers that prioritize robust emissions data and commit to actionable measures for CO₂ reduction. These collaborations could include clear emission reduction road maps and integrate emission reduction metrics into core supplier performance management processes to foster joint accountability in reducing emissions.
 - **Making proactive modifications.** It is essential to modify underlying recipes or chemistries and transition to alternative sustainable materials, such as bio-based or circular raw materials, wherever possible, without compromising product quality.

⁶⁷“Futureproofing supply chains in an evolving pharmaceutical industry,” *Pharmaceutical Technology*, n.d., accessed February 6, 2025.

⁶⁸McKinsey analysis.

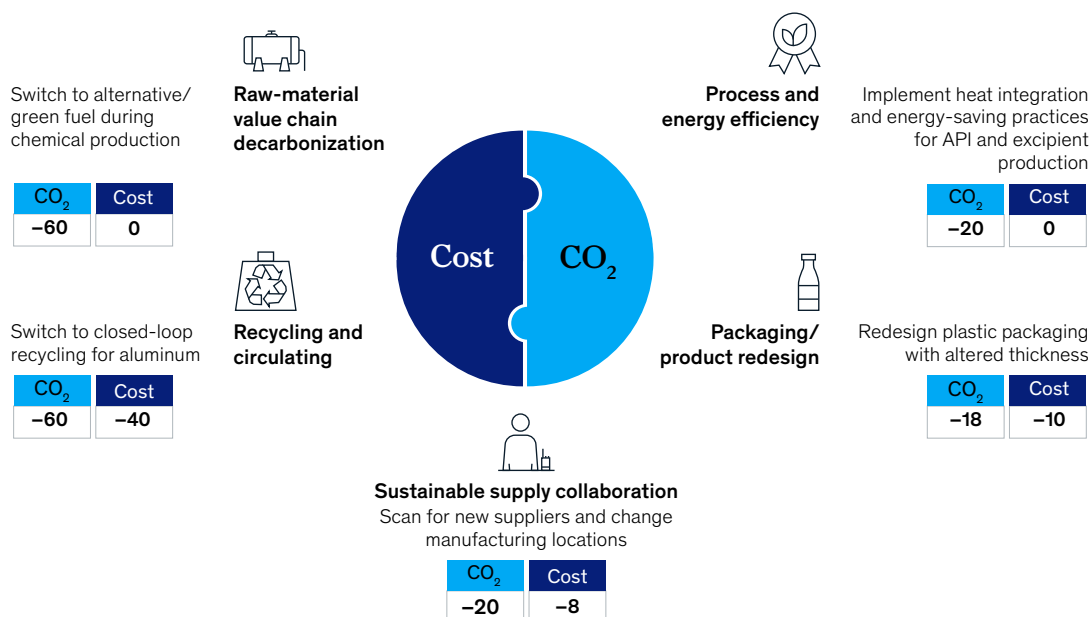
⁶⁹Concepción Jiménez-González, Alan D. Curzons, David J. C. Constable, and Virginia L. Cunningham, “Cradle-to-gate life cycle inventory and assessment of pharmaceutical compounds,” *International Journal of Life Cycle Assessment*, March 2004, Volume 9, Number 2; McKinsey analysis.

⁷⁰Concepción Jiménez-González, Alan D. Curzons, David J. C. Constable, and Virginia L. Cunningham, “Cradle-to-gate life cycle inventory and assessment of pharmaceutical compounds,” *International Journal of Life Cycle Assessment*, March 2004, Volume 9, Number 2; McKinsey analysis.

Exhibit 22

Cost savings and carbon savings: The dual-mission approach to decarbonization consists of five levers.

Dual-mission initiatives for carbon savings and cost, potential % change in carbon emissions or costs



Note: Illustrative example for a typical pharmaceutical player.
Source: Expert interviews; McKinsey analysis.

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A dual-mission green network strategy, with its long-term advantages, could be an attractive choice for forward-thinking pharma companies dedicated to sustainability. Proactive at-scale adopters of such efforts will gain early-mover advantages across markets and strategic distance from competitors in their core business operations.

The Indian pharma industry has been on a decade-long journey toward growth, reliability, and resilience. As the environment continues to evolve rapidly over the next several years, the industry has a unique opportunity to shape the next S-curve of performance.

Companies could invest to future-proof their operations setups and strive to deliver industry-beating agility, efficiency, reliability, quality, and sustainability. Doing so will require a carefully crafted approach to reimagining operations strategies, driving the next wave of technology adoption, and enhancing the quality of talent and competencies in operations.

Done right, these efforts could boost the growth of India's pharma industry, unlocking new opportunities for global leadership.

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