Beyond the horizon

Designing the chemical supply chain for a decade of uncertainty

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Foreword by KPMG in India

The chemical industry is entering a decade where uncertainty is becoming the operating context. Geopolitical fragmentation, maritime chokepoint risks, climate linked disruptions, feedstock volatility, regulatory divergence, and changing customer expectations are challenging supply chain models built primarily around scale and efficiency. Future competitiveness might depend on the ability to sense disruption early, absorb shocks, and reconfigure supply chains with speed and discipline.

For India, this moment presents both opportunity and responsibility. The country has strong domestic demand, a growing manufacturing base, policy momentum, and the ambition to play a larger role in global chemical value chains. However, this potential might be realized only if structural bottlenecks across feedstock security, logistics infrastructure, regulatory predictability, hazardous cargo handling, multimodal connectivity, and export reliability are addressed with urgency.

A central message of this report is that resilience must be designed into supply chains, not improvised during disruption. Backward integration, diversified sourcing, strategic inventory buffers, port linked chemical clusters, specialised warehousing, and risk-based continuity planning are becoming strategic necessities. India's infrastructure and logistics platforms must now translate into safe, efficient, and reliable chemical movement.

The report also highlights the emergence of intelligent, adaptive supply chains. AI enabled planning, real time control towers, digital twins, IoT based visibility, blockchain enabled traceability, and agentic decision support are shifting supply chains from reactive systems to connected networks that can anticipate disruption, simulate options, and act within commercial, safety, and regulatory guardrails.

Sustainability is becoming equally decisive. Chemical logistics might increasingly be assessed not only on cost and service, but also on carbon intensity, Scope 3 transparency, circularity, safety, and compliance credibility. Companies that embed sustainability into supply chain decisions might be better positioned to protect market access, strengthen trust, and improve long term competitiveness.

This report, developed jointly by the Indian Chemical Council and KPMG in India, seeks to support a forward-looking dialogue on the future of chemical logistics and supply chains. We hope it encourages industry leaders, policymakers, logistics partners, technology providers, and financial institutions to work together in building supply chains that are resilient, intelligent, sustainable, and globally trusted. We thank ICC for its continued leadership in advancing this agenda.

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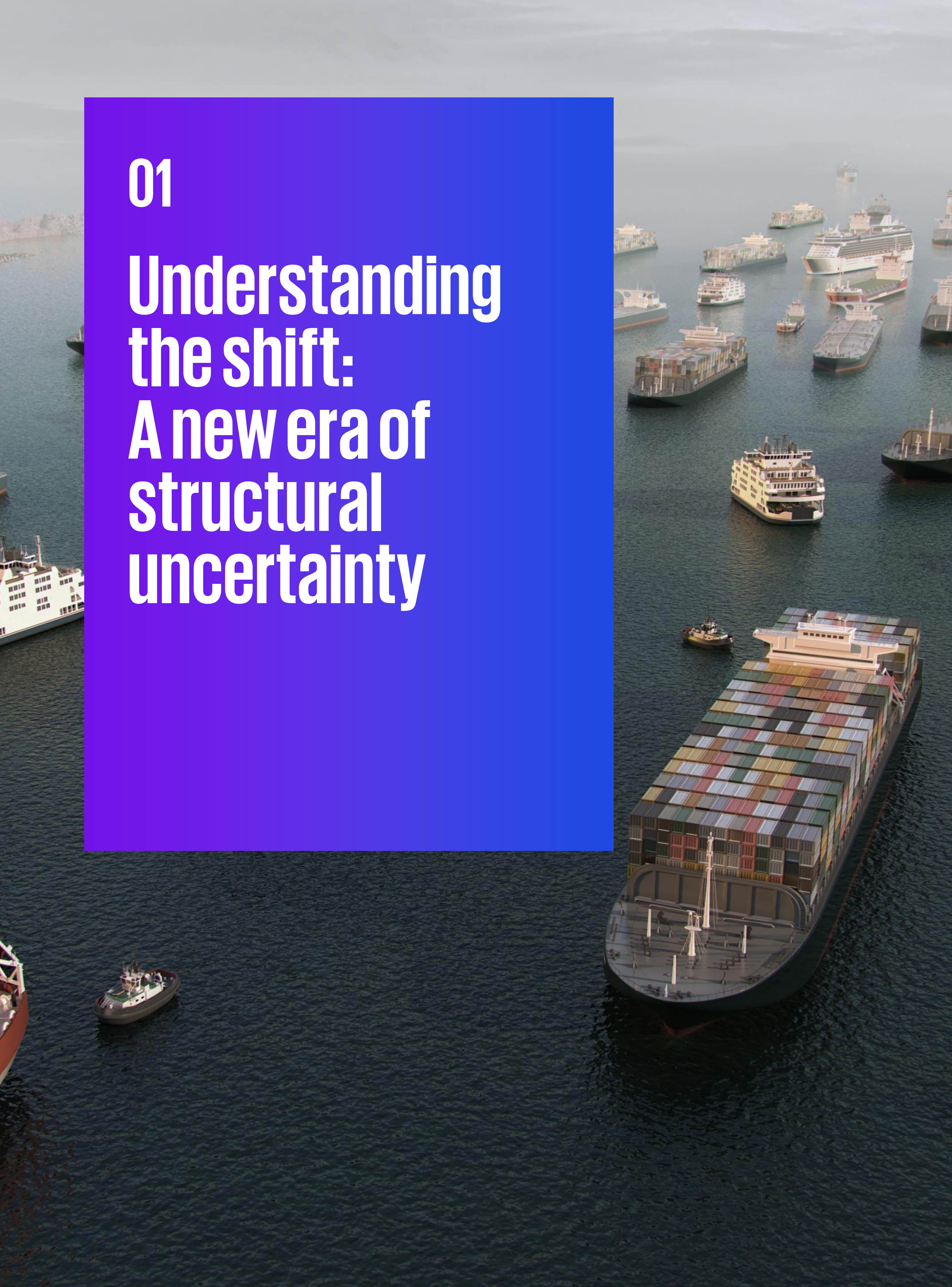


01

Understanding the shift: A new era of structural uncertainty

Introduction

The global chemical industry is entering a period of profound structural change. For decades, supply chains were designed around efficiency, scale, and globalisation, enabling companies to source raw materials, manufacture products, and serve customers through highly interconnected global networks. Today, that operating model is being fundamentally challenged by a convergence of geopolitical tensions, climate disruptions, shifting demand patterns, and evolving regulatory expectations.

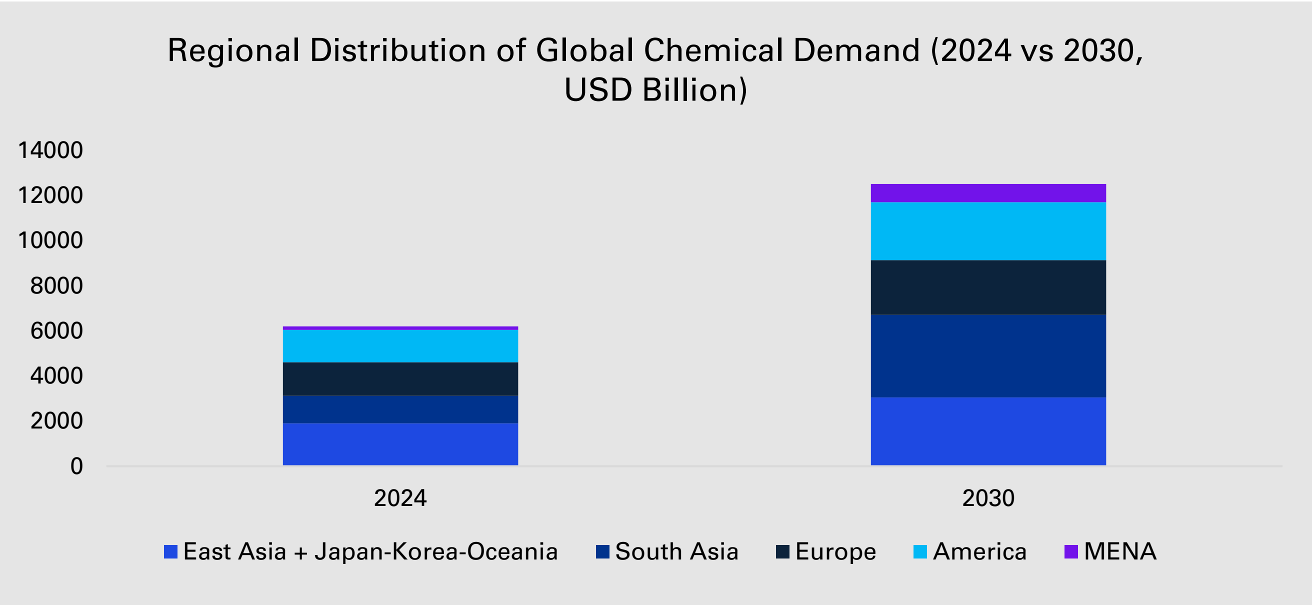
What were once considered temporary disruptions are now emerging as persistent and compounding sources of uncertainty. Trade fragmentation, supply chain bottlenecks, energy market volatility, and sustainability imperatives are reshaping how chemical companies evaluate sourcing strategies, manufacturing footprints, and investment decisions. In this evolving landscape, resilience, agility, and adaptability are no longer supplementary to cost competitiveness; they are becoming core strategic priorities.

At the same time, the geography of growth is steadily shifting. New consumption centers are emerging across Asia, the Middle East, and Africa, while advancements in technology and sustainability are accelerating the transition toward higher-value and specialized chemical products. These dynamics are not only redefining demand patterns but also altering the structure of the industry itself. Together, these forces signal a fundamental transition from globally optimized, linear supply chains to more diversified, regional, and interconnected networks designed for a world of sustained uncertainty.

The evolving global chemical ecosystem – Evolving demand centers

The global chemical ecosystem is undergoing a significant transformation, driven by shifting demand centers, evolving industrial priorities, and changing customer expectations. While developed economies continue to account for a substantial share of global chemical consumption, future growth is increasingly being led by emerging markets. The global chemical industry, valued at over USD6 trillion, is projected to nearly double by 2030, with a significant share of this growth concentrated in emerging economies.

Historically, North America, Western Europe, and Japan served as the primary engines of global chemical consumption. However, demographic maturity, slower economic growth, and market saturation have moderated demand expansion in these regions. In contrast, emerging economies are witnessing accelerated demand across key sectors such as construction, transportation, healthcare, and energy transition. As a result, demand is becoming more geographically distributed, with Asia projected to account for nearly 65 per cent[1] of global chemical sales by 2030, driven largely by South and East Asia.



1. OECD - Chemical Safety and Biosafety and KPMG in India 2025 analysis

The evolving global chemical ecosystem – Shift in consumer preferences

At the same time, the industry is witnessing a structural divergence between commodity and specialty chemical segments. Commodity chemicals remain scale-driven and cyclical, while specialty chemicals, characterized by higher margins, innovation, and customization, are increasingly driving value creation. Demand for specialty chemicals is expanding across high-growth sectors such as electronics, pharmaceuticals, advanced materials, and clean energy, and is expected to grow faster than bulk chemicals.

This divergence is reshaping industry structure and strategic priorities. While commodity chemicals rely on globally integrated, efficiency-focused supply chains, specialty chemicals require more localized, agile, and customer-centric models. Together with shifting demand geographies, these trends are driving companies to realign production footprints and adopt more diversified, regionally anchored supply chains.

Parameter	Commodity Chemicals	Specialty Chemicals
Primary Driver	Scale & Cost Efficiency	Innovation & Performance
Margin Profile	Cyclical	Relatively Resilient
Product Differentiation	Low	High
Customer Relationship	Transactional	Solution-Oriented
Supply Chain	Efficiency-focused	Responsive & Agile
Growth Outlook	Moderate	Strong

The growing divergence between commodity and specialty chemicals is accelerating a shift toward higher-value, innovation-driven segments, prompting companies to invest in differentiated products and regionally aligned supply chains.

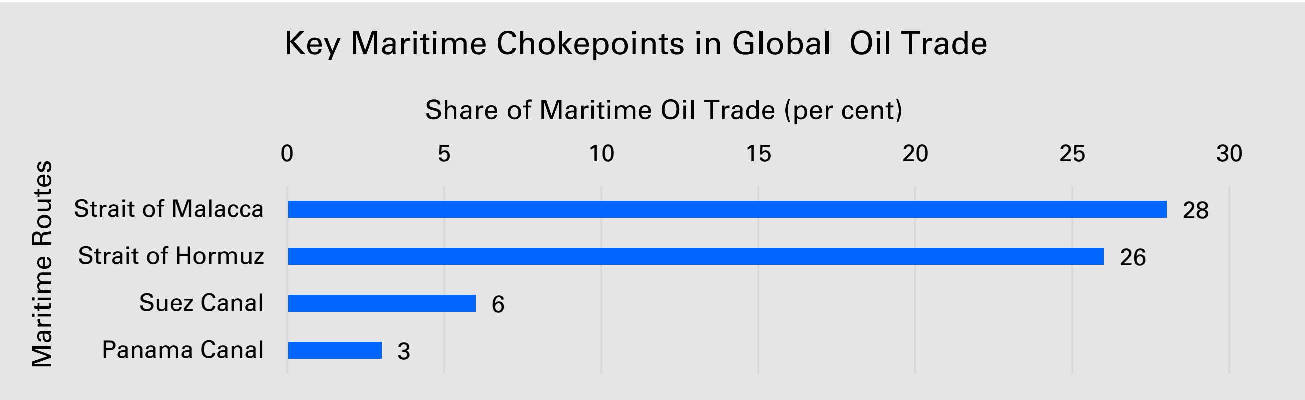
The Age of Permacrisis in supply chains

The global chemical industry is increasingly operating in an environment defined by persistent and overlapping disruptions, often described as a "permacrisis." What were once episodic shocks have evolved into a continuous cycle of geopolitical tensions, logistics constraints, climate events, and economic volatility. The COVID-19 pandemic marked a structural inflection point, with global container freight rates rising and delivery delays increasing sharply, exposing deep vulnerabilities in global supply chains.

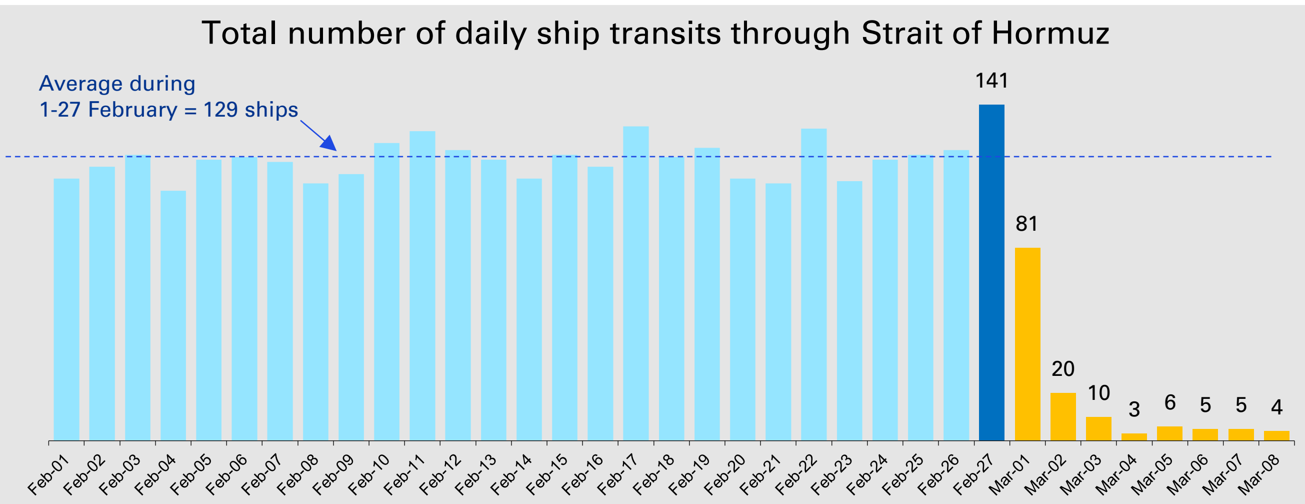
Since then, disruptions have become both more frequent and more interconnected. The recent ongoing geopolitical tensions, have affected the fragility of global logistics networks. The chemical industry, with its reliance on energy-intensive production and globally dispersed supply chains, is particularly exposed. As a result, disruption is no longer treated as an exception but as a structural feature of the operating environment, requiring companies to redesign supply chains for resilience, flexibility, and risk mitigation.

Maritime Chokepoints and Logistical Vulnerabilities

Supply chain vulnerability is further impacted by the concentration of global trade flows through a limited number of maritime chokepoints. The Suez Canal carries approximately 6 per cent of global oil trade, the Strait of Hormuz accounts for ~26 per cent of global oil flows, and the Panama Canal handles ~3 per cent of world trade[2]. These corridors represent critical points where localized disruptions can have disproportionate global impacts.



This vulnerability has materialized in recent years, notably in the Strait of Hormuz. Recent tensions between the United States and Iran in 2026 triggered one of the largest energy supply disruptions in history, with shipping traffic through the Strait of Hormuz declining by 70-90 per cent[3] and periods of near-total closure that stranded vessels and severely constrained global oil supply.

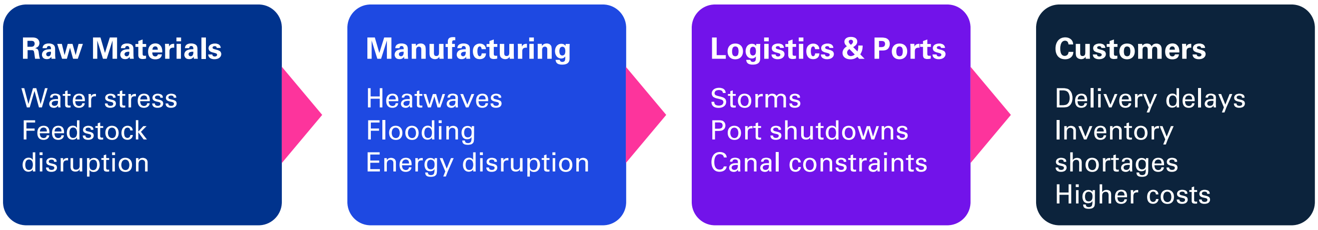


2. U.S. Energy Information Administration (EIA), 2026
3. Strait of Hormuz disruptions: Implications for global trade and development - UNCTAD, 2026

Climate Disruptions

Climate-related disruptions are emerging as a critical driver of supply chain risk, with increasing frequency and intensity of extreme weather events impacting logistics networks. Climate-related disasters have increased in recent decades, and many natural disasters are weather- and water-related, highlighting systemic risks to infrastructure and trade. Maritime logistics, which underpins global supply chains, is particularly exposed, increasing the risk of cascading disruptions across regions.

The impact on critical infrastructure is already evident. Climate-induced droughts have disrupted key trade routes such as the Panama Canal in the past, while floods, storms, and heatwaves continue to affect ports and industrial clusters. For the chemical industry, which is highly dependent on water, energy, and coastal infrastructure, these disruptions directly affect production continuity and supply chain reliability, accelerating the shift toward more resilient and adaptive supply chain design



Climate-related disruptions propagate across multiple stages of the chemical supply chain, creating cascading impacts from upstream to downstream. As shown, risks at the raw material stage (water stress, feedstock disruption) affect production, while heatwaves and flooding disrupt manufacturing operations. These impacts extend to logistics through port shutdowns and transport constraints, ultimately leading to delivery delays, inventory shortages, and higher costs for customers. This interconnected risk amplification highlights the need for more resilient and adaptive supply chain design.

A very recent example, in 2025, European heatwave caused severe drought conditions that reduced water levels in key inland shipping routes such as the Rhine and Danube. This forced vessels to operate at only 30-40 per cent[4] of their normal capacity, significantly constraining the transport of critical raw materials including chemicals and energy inputs. As a result, freight costs surged by up significantly while reduced feedstock availability led to production constraints and supply bottlenecks across industrial value chains.

Macroecomonic volatility and input cost shocks

Geopolitical tensions and trade fragmentation are increasingly reshaping global supply chains by altering trade flows, sourcing strategies, and market access. The number of global trade restrictions has increased more than fivefold[5] since 2015, reflecting a structural shift toward tariffs, economic security policies, and localization requirements. For the chemical industry, this increases exposure to input cost volatility, regulatory divergence, and cross-border operational complexity

Macroeconomic volatility has emerged as a key source of supply chain uncertainty, driven by sharp fluctuations in commodity and energy markets. Real commodity prices increased sharply between 2020 and 2022, with several segments experiencing increases exceeding 100 per cent, while crude oil prices also rose significantly in early 2022[6] due to supply disruptions and geopolitical tensions. Such volatility directly impacts sourcing, pricing, and production planning across global supply chains.

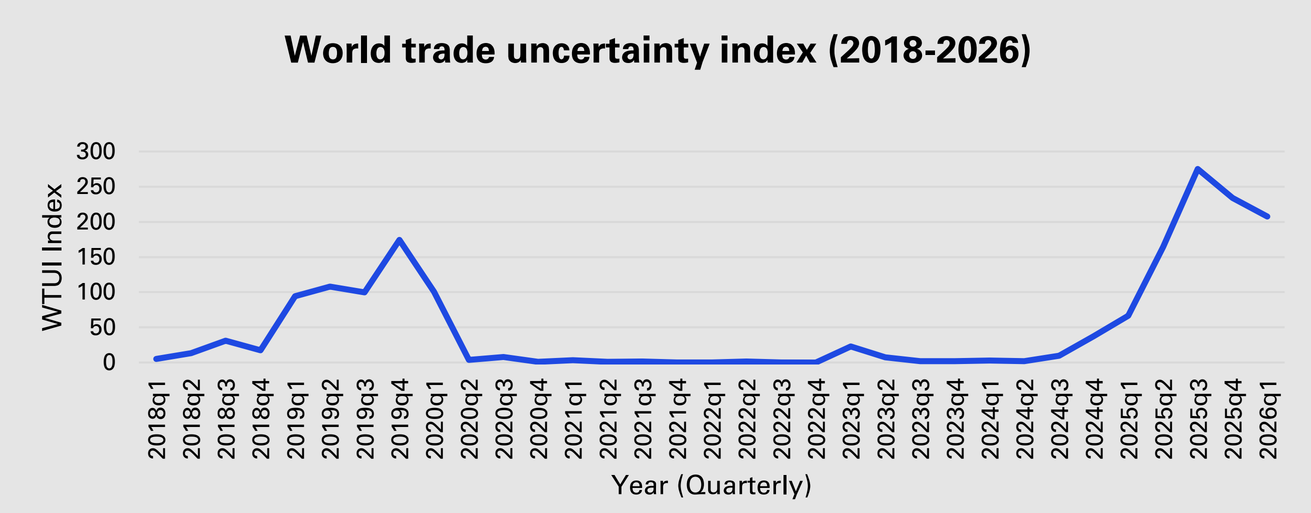
The chemical industry is particularly exposed due to its high dependence on energy and hydrocarbon feedstocks, making it one of the largest industrial energy consumers globally. Fluctuations in energy prices, exchange rates, and interest rates significantly affect production economics, margins, and competitiveness. As a result, companies are adopting dynamic planning, scenario-based analysis, and integrated risk management to navigate sustained cost and demand volatility.

The challenge for chemical supply chains is shifting from managing isolated shocks to navigating sustained cost volatility, where resilience, flexibility, and real-time decision-making are becoming critical competitive differentiators..

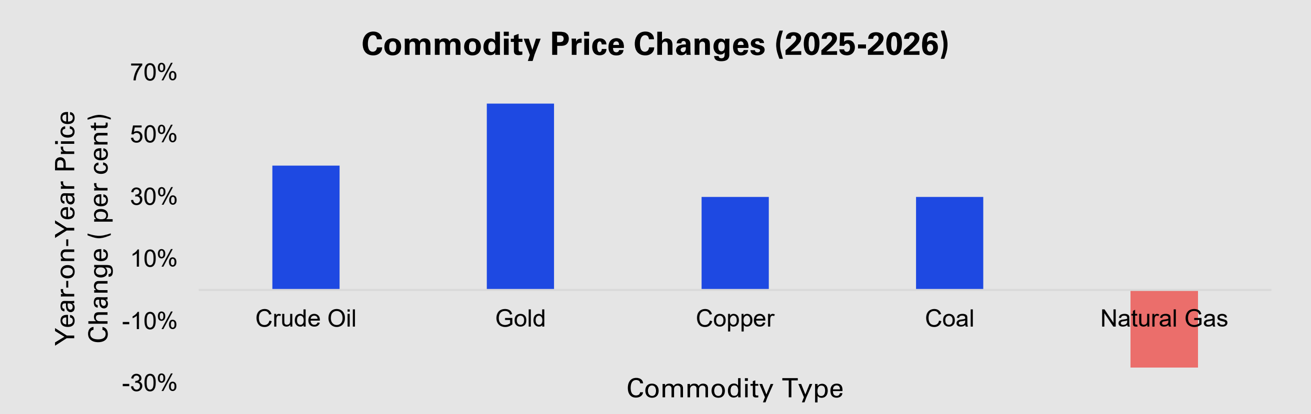
4. Low water levels push up shipping costs on Europe's rivers amid heatwave - The Guardian, 2025
5. World Bank Global Trade, 2025
6. UN Trade and Development, 2025

Redesign of global supply networks

The structural shifts reshaping the global operating environment are driving a fundamental redesign of supply networks. Traditional supply chain models optimized primarily for cost efficiency are increasingly being challenged by the need for resilience, flexibility, responsiveness, and trust. As organizations seek to manage uncertainty more effectively, supply network design is evolving from a purely operational consideration to a strategic business priority.



The World Trade Uncertainty Index (WTUI) shows a sharp resurgence in global trade-related uncertainty since 2024, reaching peak levels in 2025[7]. This reflects intensified geopolitical tensions, trade fragmentation, and supply disruptions, indicating that uncertainty is no longer episodic but a persistent structural feature of the global operating environment...



Commodity markets exhibit significant divergence in price movements over the past year, with crude oil (+40 per cent), gold (+60 per cent), and industrial commodities such as copper and coal (~30 per cent) recording strong increases, while natural gas declined (~-25 per cent)[8]. These movements reflect differing underlying drivers, including geopolitical disruptions, safe-haven demand, and supply–demand imbalances.

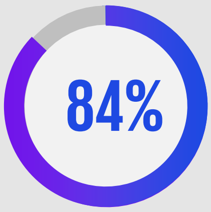
This divergence closely aligns with the rise in global uncertainty captured by the World Trade Uncertainty Index. As uncertainty increases, commodity markets become more volatile due to disruptions in supply chains, shifting demand patterns, and changing investor behavior. Safe-haven assets such as gold tend to surge during periods of uncertainty, while energy and industrial commodities respond to geopolitical and economic conditions.

Consequently, rising global uncertainty is directly translating into increased volatility and unpredictability in input costs, making traditional cost-optimized supply chains less viable and reinforcing the need for more resilient, diversified, and adaptive supply network models.

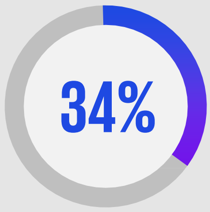
7. IMF Commodity Price Data, 2026
8. IndexMundi Commodity Price Data, 2026

As a result, companies are fundamentally rethinking how supply networks are structured and managed. For several decades, globalization encouraged firms to concentrate production in locations offering maximum cost efficiency and scale. However, recent disruptions have exposed the risks of excessive geographic concentration. As a result, companies are increasingly shifting toward regionalized supply networks, with firms actively transitioning from global to regional supply chains and a growing share sourcing inputs closer to production.

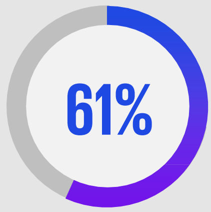
KPMG 2025 Global Energy, Natural Resources and Chemicals CEO Outlook[9]



Executives are confident in the industry growth



Agree that supply chain resilience is one of the top challenges driving short-term decisions



Prioritizing regional distribution strategies to enhance resilience and reduce lead times

From "China+1" to "China + Many"

Evolution of Manufacturing Diversification Strategies

China only
Cost efficiency
Single hub
High concentration risk

China + 1
Partial diversification
Backup sourcing Reduced concentration risk

China + Many
Multi-country network
High flexibility
Low concentration risk

Supply networks are evolving from centralized global models toward distributed, regional configurations that enhance resilience and responsiveness. Historically, supply chain performance was measured primarily through cost, inventory, and operational efficiency. However, persistent disruptions have expanded performance priorities to include resilience, agility, and visibility. As a result, investments in digital visibility and risk management are accelerating investments in supply chain visibility tools and digital risk management capabilities to support real-time decision-making.

One of the most visible manifestations of supply chain redesign is the shift away from concentrated manufacturing in China toward diversified sourcing strategies. While China remains central to global manufacturing, companies are increasingly pursuing risk diversification, with many of the firms actively reducing their dependence on China and a significant share adopting nearshoring strategies. This reflects a broader transition toward "China+1" models, where organizations build additional capacity in alternative locations to reduce exposure to single-country risks.

This strategy is now evolving into "China + Many," where production is distributed across multiple regions rather than a single alternative hub. With executives planning to bring supply chains closer to key markets, firms are building multi-location manufacturing networks that enhance flexibility, responsiveness, and resilience. This shift reduces geographic concentration risk while enabling companies to respond more effectively to regional demand dynamics and geopolitical uncertainty.

9. KPMG ENRC CEO Outlook, KPMG in India, 2025

As supply chains become more regionally distributed, new manufacturing hubs are emerging as critical nodes in global production networks. Companies are bringing operations closer to key markets, accelerating investments in regions such as India, ASEAN, and Eastern Europe. These regions are gaining traction due to cost competitiveness, improving infrastructure, and stronger integration into regional demand ecosystems rather than as substitutes for China.

India, in particular, is emerging as a key hub, with companies identifying the Indian subcontinent as a preferred manufacturing destination. ASEAN economies continue to capture export-led production, while Eastern Europe and the Middle East benefit from proximity to major markets and resource advantages. Together, these regions are enabling a more distributed production landscape, improving regional responsiveness while supporting long-term supply chain resilience

Globalisation

- Cost Efficiency
- Centralized Production

Regionalisation

- Proximity
- Risk Reduction

Multi-Polar Networks

- Resilience
- Flexibility

02

Solving for today: Building resilience in the Indian context

India's strategic opportunity in a fragmented global chemical landscape

India as a global supply chain anchor

The global chemical industry is undergoing a structural realignment driven by geopolitical tensions, supply chain disruptions, and increasing risk diversification strategies. In this context, India is emerging as a potential anchor within global supply chains. The Indian chemical industry plays a pivotal role in the nation's manufacturing ecosystem, accounting for approximately 7 per cent of India's GDP. [10]

India's market fundamentals are strong:

- Large and growing domestic demand base
- Integrated downstream industries (pharma, agriculture, textiles)
- Established industrial clusters

At the same time, India's current global integration remains limited. India's share in global chemical value chains at only **~3.5 per cent**[11], indicating significant headroom for expansion. It is estimated that India could scale its chemical industry to **USD1 trillion by 2040**[12], reinforcing its long-term relevance in global supply chains.

USD1010 Bn	3x	USD1060 Mn
India's projected chemical market size in 2040 expected to grow at a CAGR of 9.6 per cent [13] from 2025	India's global chemical market share by 2040 from 4 per cent today to 11 per cent in 2040 [14]	Total FDI made in Chemicals and Petrochemicals sector in 2025[15]

India's emergence as a global supply chain anchor might depend primarily on its ability to translate its large industrial base into globally competitive production ecosystems, rather than relying solely on cost advantages. The country's extensive domestic consumption and its role as the sixth-largest chemical producer worldwide[7] create a strong foundation for scaling manufacturing and supporting diverse downstream industries such as pharmaceuticals, agriculture, and construction,

However, India's relatively modest participation in global chemical trade networks indicates that scale alone has not yet translated into global integration. Therefore, India's differentiation might hinge on converting its domestic scale into consistent export capability and supply reliability, positioning itself as a stable and diversified alternative in global value chains rather than a purely cost-driven manufacturing base.

Role in global diversification strategies

Global companies are increasingly diversifying supply chains to reduce overdependence on specific geographies. This is particularly relevant in chemicals, where concentration risks in upstream supply chains have been exposed in recent years.

India aims to increase its share in global chemical value chains to 11 per cent by 2040[16], supported by targeted industrial policies and ecosystem development.

India's positioning is supported by:

- Government-led industrial corridors and chemical clusters (PCPIRs)
- Trade agreements improving market access
- Incentives for domestic manufacturing

However, the sector remains fragmented with limited integration across value chains.

India's emergence as a global supply chain anchor might be primarily driven by scale and policy, supported by cost advantages. Strong domestic demand and integrated end-use industries provide scale, while policy initiatives such as PCPIRs, PLI schemes, and the National Logistics Policy are enabling ecosystem development and efficiency gains. However, cost competitiveness alone is insufficient, as logistics still account for 8 per cent of GDP[17], affecting efficiency. Thus, India's ability to translate policy into execution at scale might determine whether it can shift from a cost-competitive manufacturing base to a resilient global supply chain

10,11,12,14,16. Niti Aayog, Chemical Industry: Powering India's participation in Global Value Chains, June 2025
13. KPMG in India 2026 analysis
15. Chemi-Sankhya 2025
17. Assessment of Logistics Cost in India - DPIIT–NCAER, September, 2025

2.2 Key Bottlenecks in India's Chemical Supply Chains

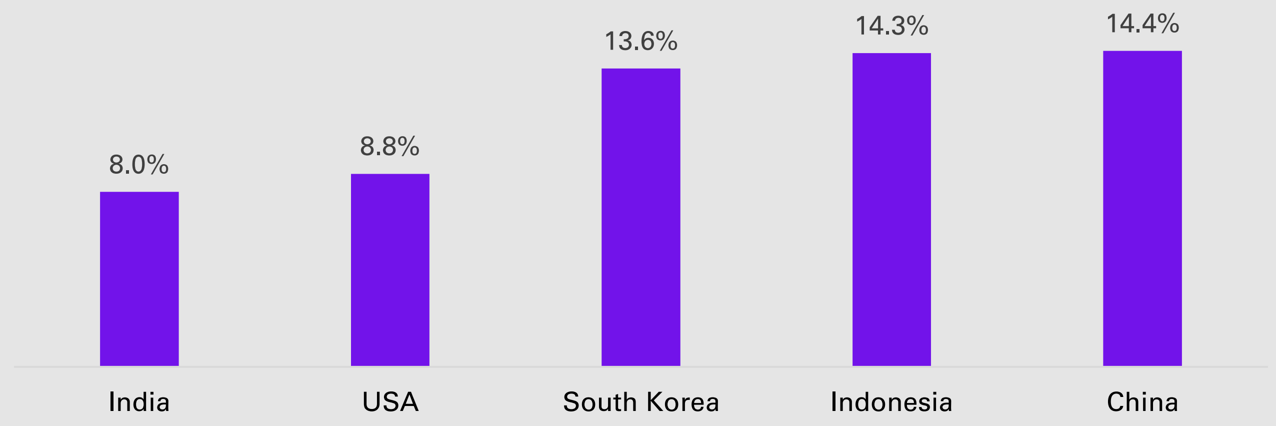
India's chemical sector stands at a strategic inflection point, supported by strong domestic demand, geopolitical tailwinds, and policy backing. However, the sector's ability to translate these advantages into sustained global competitiveness is constrained by a set of persistent structural bottlenecks. These challenges are not demand-driven but rooted in infrastructure limitations, import dependence, and regulatory inefficiencies. Together, they create systemic friction that inflates costs, increases risk exposure, and limits India's ability to emerge as a resilient global supply chain hub.

Infrastructure gaps and logistics costs

Logistics efficiency remains a critical determinant of competitiveness for India's chemical sector. Logistics performance reflects the ability to move goods with speed, reliability, and at low cost. The Logistics Cost as a per cent of GDP measures efficiency, quality of infrastructure, and ease of supply chain operation. Infrastructure deficiencies continue to represent one of the most immediate and measurable constraints on supply chain performance, although recent policy interventions are beginning to drive gradual improvement.

Historically, India's logistics costs ranged between 13–14 per cent of GDP[18], significantly higher than the global benchmark of 8–10 per cent[19], creating a structural cost disadvantage for exporters and manufacturers alike. More recent estimates indicate that logistics costs have moderated to 8 per cent[20] of GDP in FY 2023–24, suggesting tangible progress driven by initiatives such as GatiShakti and investments in freight corridors.

Logistics Cost as per cent of GDP[21]



However, these improvements coexist with persistent system-level inefficiencies that continue to constrain sectoral performance. For the chemical industry, these inefficiencies are further amplified due to the specialised nature of operations, particularly in the safe handling, storage, and transportation of hazardous materials. Key structural gaps include:

- Fragmented multimodal connectivity between chemical manufacturing clusters and ports
- Limited availability of dedicated hazardous chemical logistics corridors
- Inadequate specialised warehousing and temperature-controlled storage infrastructure
- Capacity constraints in port infrastructure for handling hazardous materials

In addition to these sector-specific gaps, broader system inefficiencies remain entrenched:

- Continued reliance on road transport, which is costlier and less efficient compared to rail and inland waterways
- Regional imbalances in logistics infrastructure, resulting in uneven access to efficient supply chain networks
- Persistent last-mile connectivity challenges, particularly affecting chemical clusters located away from major logistics hubs

18, 19, 20, 21. Assessment of Logistics Cost in India - DPIIT–NCAER, September, 2025

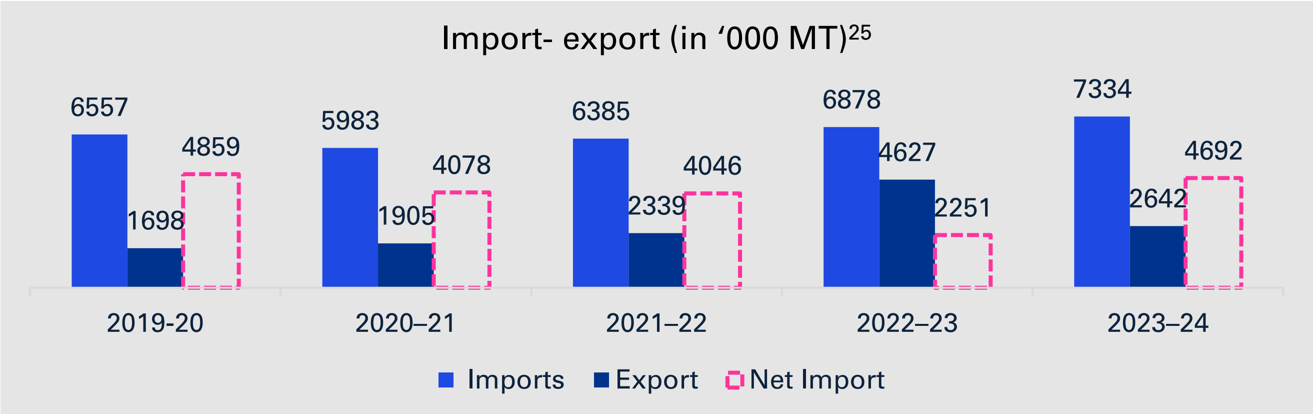
There are significant disparities across firms, underscoring the uneven impact of infrastructure constraints:

- Small firms incur logistics costs of up to ~16.9 per cent[22] of output, reflecting limited scale and bargaining power
- Large firms operate at ~7.6 per cent[23], benefiting from scale efficiencies and better access to integrated logistics networks

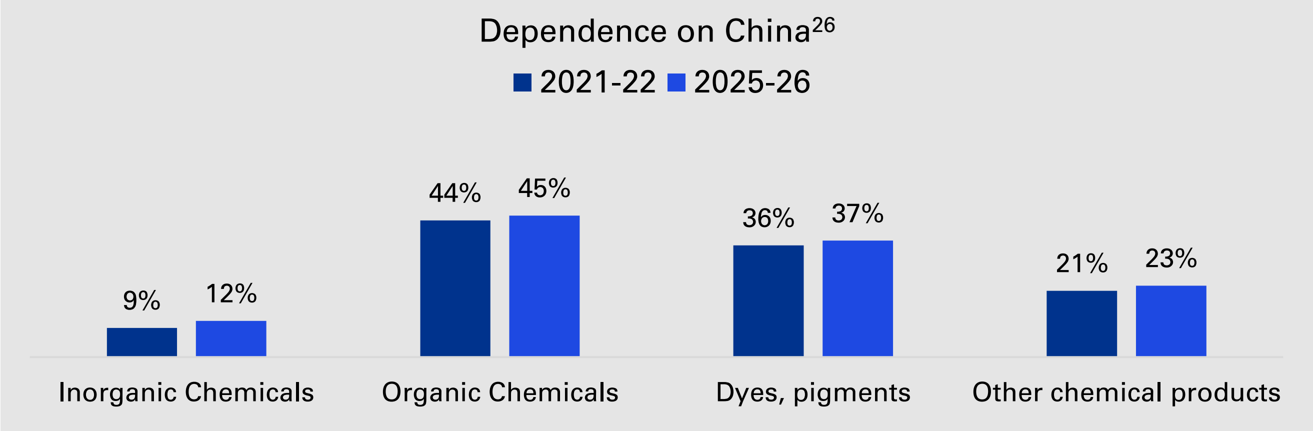
Despite strong progress under programmes such as GatiShakti, Dedicated Freight Corridors, and Multimodal Logistics Parks, the benefits remain unevenly distributed across regions and industry segments. As a result, logistics inefficiencies continue to impact delivery reliability, working capital through higher inventory buffers, and overall export competitiveness for India's chemical manufacturers.

Import dependencies and feedstock vulnerabilities

India's chemical supply chain continues to face a fundamental structural constraint-its high dependence on imported feedstocks and intermediates. Despite strong domestic demand and expanding downstream capabilities, the sector remains heavily reliant on global supply chains for critical raw materials, particularly petrochemical derivatives and specialty inputs. This dependence has led to a persistent trade imbalance, with a chemical trade deficit estimated at approximately USD31 billion (2025)[24], underscoring the scale of import reliance.



At a structural level, India remains significantly dependent on imported petrochemical intermediates and key feedstocks, exposing the industry to global supply-chain disruptions and price volatility. A critical dimension of this vulnerability is the concentration of sourcing geographies. India imports a substantial share of its chemical intermediates from a limited set of regions, particularly China and parts of West Asia.



22 and 23. Assessment of Logistics Cost in India - DPIIT–NCAER, September, 2025
24. Chemical Industry: Powering India's participation in Global Value Chains - Niti Aayog, June 2025
25. Chemical and petrochemical statistics at a glance - Department of Chemicals & Petrochemicals, 2024
26. EXIM data, 2026

A key underlying driver of this structural exposure is the absence of adequate backward integration within India's chemical ecosystem. While the country has developed strong capabilities in downstream manufacturing and formulations, investment in upstream petrochemical capacity and feedstock production has not kept pace with demand growth. This imbalance limits the ability of domestic firms to secure critical inputs internally and constrains resilience during periods of global disruption.

However, until these investments translate into operational capacity, India's chemical supply chain might remain exposed to external shocks. This structural imbalance constrains the country's ability to position itself as a reliable global supplier, as upstream vulnerabilities can rapidly cascade into downstream production disruptions, cost volatility, and reduced competitiveness in global markets.

Safety, compliance, and regulatory friction

Despite the presence of a broad regulatory architecture, the current framework is characterized by fragmentation, procedural complexity, and uneven enforcement, which collectively create operational inefficiencies and elevate systemic risk. India's chemical industry operates under a multi-layered regulatory regime spanning central and state authorities. Key legislations include the Manufacture, Storage and Import of Hazardous Chemicals Rules, the Factories Act, 1948, and a range of environmental and pollution control regulations administered by the Ministry of Environment, Forest and Climate Change (MoEFCC). The government is working toward a more comprehensive and globally aligned framework through the Chemicals Management and Safety Rules (CMSR), commonly referred to as India-REACH.

However, the approval process for new chemical projects often requires coordination across multiple regulatory authorities, which can extend implementation timelines to 18–24 months[27] in some cases. Overlapping jurisdiction across regulatory bodies further compounds delays, increasing administrative burden and compliance complexity for industry participants. In addition, the continued reliance on legacy regulations-some dating back to the late 1980s-limits the sector's ability to keep pace with the evolving complexity of global chemical supply chains. The ongoing development of the Chemical (Management and Safety) Rules (CMSR) reflects India's efforts to establish a comprehensive chemicals management framework and enhance harmonization with global standards, including REACH, GHS, and the IMDG Code.

255 days
Time Taken for an EC Approval in India[28]

89 per cent
Projects for which grant of EC was delayed[29]

194 days
Avg. delay in grant of EC approval[30]

1005 days
Max delay in grant of EC approval[31]

The implications of these gaps are both operational and strategic. From a safety perspective, variations in standardization and enforcement across the sector can contribute to operational risks in the transportation and handling of hazardous materials. Recent chemical transit incidents and industrial accidents have highlighted the need for continued improvements in compliance systems, process safety, and hazardous material management practices.From a commercial standpoint, regulatory inefficiencies translate into tangible costs. Extended approval timelines delay capital investment and capacity expansion, while complex compliance requirements increase overheads-particularly for small and mid-sized enterprises.

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27,28,29,30,31. Niti Aayog, Chemical Industry: Powering India's participation in Global Value Chains June 2025

Strengthening domestic supply chain resilience

Addressing these bottlenecks requires a coordinated and time-bound response across industry and policy stakeholders. A four-pronged resilience strategy-focused on integration, diversification, digitization, and regulatory reform-can significantly enhance the robustness and global competitiveness of India’s chemical supply chains.

Backward integration and local ecosystem development

Backward integration represents one of the most structurally transformative levers to strengthen India’s chemical supply chain resilience and reduce its dependence on imported feedstocks and intermediates. By expanding domestic production capabilities into upstream feedstocks and critical intermediates, chemical companies can significantly mitigate supply disruptions, stabilise input costs, and capture greater value within the domestic ecosystem. The need for this shift is underpinned by structural constraints in the current value chain. Limited domestic feedstock production, fragmented industrial linkages, and high reliance on imports have collectively constrained competitiveness and contributed to a chemical trade deficit of approximately USD31 billion[32]. This dependence exposes the industry to global supply shocks, price volatility, and geopolitical risks, reinforcing the urgency of developing a more integrated and self-reliant ecosystem. Encouragingly, both industry and government are increasingly aligning toward this agenda. Large-scale capital commitments signal a decisive shift toward upstream capacity creation.

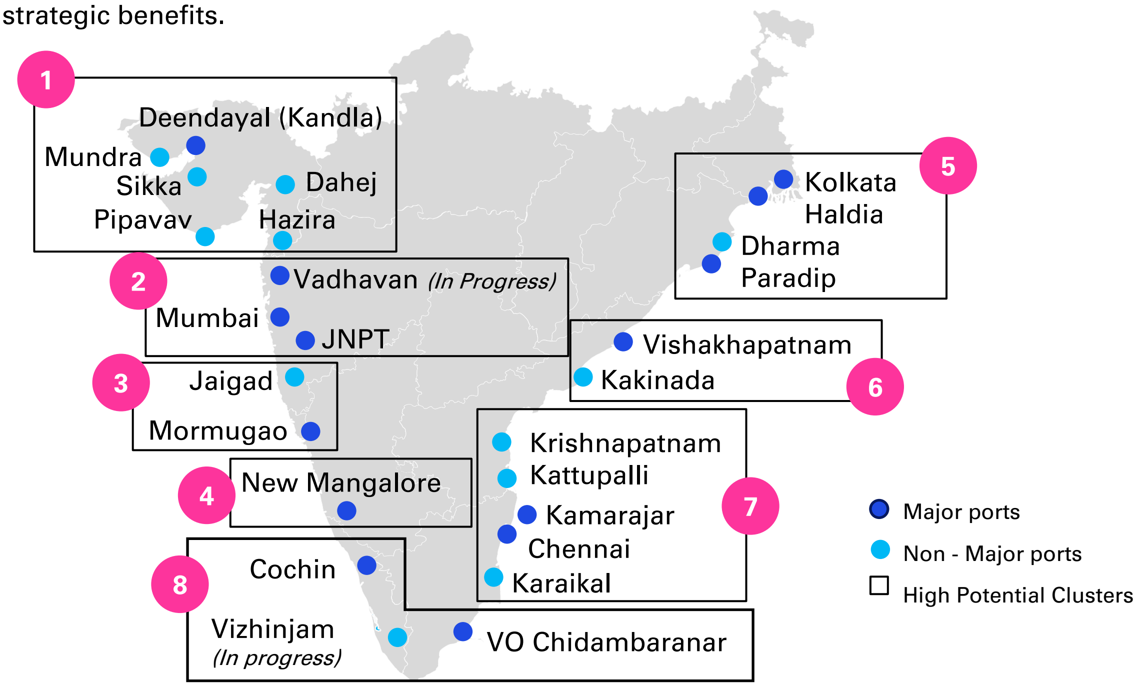
USD37 Bn

India's petrochemical sector planned capital expenditure - one of the largest backward integration investment program in the sector's history[33]

29.6 MMT -> 46 MMT

Increase in India’s petrochemical capacity by 2030[34]

In parallel, the Government of India has introduced targeted policy interventions to enable integrated ecosystem development. A key initiative is the development of Petroleum, Chemicals and Petrochemicals Investment Regions (PCPIRs)-large-scale industrial zones designed to co-locate refineries, petrochemical complexes, and downstream chemical units. Complementing this approach, cluster-based development models, including port-linked chemical hubs, are being promoted to enhance infrastructure efficiency and supply chain coordination. Such integrated ecosystems offer multiple strategic benefits.



32. Chemical Industry: Powering India’s participation in Global Value Chains - Niti Aayog, June 2025
33. India Brand Equity Foundation, 2026
34. PIB, 18 Oct 2024

First, they enhance supply security by reducing reliance on external sources and ensuring closer proximity between feedstock production and downstream manufacturing. Second, they improve cost efficiency through shared infrastructure, economies of scale, and reduced logistics overhead-particularly relevant in a market where logistics costs remain elevated relative to global benchmarks. Third, they enable industrial synergies, including by-product utilization, process integration, and cross-value chain innovation, which collectively strengthen competitiveness.

Additionally, ongoing investments in logistics infrastructure-supported by initiatives such as Sagarmala and increasing port throughput (in the FY 2024-25,total cargo handled by Major Ports rose to approximately 855 million tonnes, up from 819 million tonnes in the previous fiscal year,)[35] further reinforce these integration efforts by enabling more efficient movement of feedstocks and finished products across the value chain. From a strategic standpoint, backward integration not only addresses current vulnerabilities but also creates durable competitive advantage. Companies with integrated upstream capabilities are structurally better insulated from global supply shocks, more resilient to input price volatility, and better positioned to compete in export markets. Over the long term, this shift toward integrated chemical ecosystems aligns with national priorities such as Atmanirbhar Bharat and India's ambition to increase its share in global chemical value chains.

Supplier diversification, strategic stockpiling, and continuity planning

While backward integration offers a long-term pathway to reduce structural dependency, building immediate resilience in India's chemical supply chains requires a fundamental shift toward diversified, risk-aware sourcing strategies and robust supply continuity planning.

A central priority is supplier diversification across regions. This concentration creates significant vulnerability to disruptions, as evidenced during pandemic-related supply shocks and geopolitical tensions. In response, Indian chemical companies are increasingly adopting multi-regional sourcing strategies, balancing cost efficiency with resilience.

Means for Supplier diversification

Expand sourcing partnerships with Middle East for petchem feedstock	**Alternate manufacturing hubs in South Korea, Japan, SE Asia**	**Leverage suppliers in U.S. and Europe for specialty chemicals**	**Utilize trade framework e.g. UAE CEPA and ASEAN FTA for cost –effective diversification**	**Regional warehousing & distributed inventory networks to reduce lead-time**

Not all inputs require buffering; prioritization is typically focused on high-risk and high-impact feedstocks such as naphtha, ethylene, propylene, benzene, and methanol, which form the backbone of downstream chemical production. These inputs are closely linked to global crude markets and given that feedstock and raw material expenses represent a significant share of chemical production costs, fluctuations in energy and commodity prices can have a substantial impact on industry margins and competitiveness. Recent disruptions, including feedstock shortages driven by geopolitical tensions in West Asia, have led to temporary shutdowns of petrochemical units in India, reinforcing the importance of maintaining adequate inventory buffers

Flexible contracting models to manage price volatility and supply uncertainty. Taken together, these interventions represent a shift from traditional efficiency-driven supply chains toward resilient, regionally anchored operating models. Diversified sourcing reduces concentration risk, strategic inventory buffers ensure continuity during disruptions, and regional ecosystem development-supported by PCPIRs and port-based clusters-enhances supply security and coordination.

In the near term, this integrated approach provides the operational resilience required to navigate ongoing geopolitical and logistics uncertainties, while longer-term backward integration investments continue to strengthen the structural foundations of India's chemical supply chains.

35. PIB report, May 2025

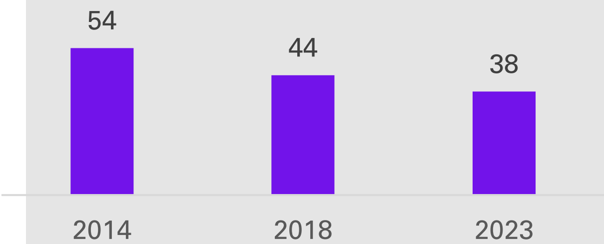
Digital transformation is emerging as a key enabler of resilient supply chains in India

Digital transformation is emerging as a critical enabler of agile, transparent, and resilient chemical supply chains in India. In an increasingly volatile operating environment-characterized by geopolitical disruptions, feedstock price fluctuations, and complex compliance requirements-the ability to sense risks in real time and respond proactively is no longer a source of incremental efficiency, but a core determinant of competitiveness.

At a systemic level, government-led digital initiatives are playing a transformative role in modernizing India's logistics ecosystem.

Platforms such as the Unified Logistics Interface Platform (ULIP) and the National Logistics Policy (NLP) 2022, are designed to integrate historically fragmented logistics systems through data standardization, digital connectivity, and real-time information sharing. These initiatives form part of a broader national agenda to reduce logistics costs and improve supply chain reliability through a data-driven, technology-enabled infrastructure. The impact of these reforms is already visible in measurable improvements in logistics performance. Supported by programs such as Sagarmala and digital integration initiatives, India has achieved significant gains in port efficiency.

India Ranking in World Bank LPI[36]



Port Turnaround time (hrs)[37]

These advancements have direct implications for the chemical sector, where the timely and safe movement of hazardous and high-value materials is critical to operational continuity.

At the enterprise level, digital adoption across Indian chemical companies is accelerating. Key investment areas include:

1. Real-time logistics and freight visibility systems
2. AI-driven demand forecasting and inventory optimization
3. Blockchain-enabled traceability and compliance management
4. Integrated control towers for end-to-end supply chain orchestration

The deployment of these technologies is already demonstrating tangible operational benefits. The adoption of advanced analytics and AI-driven forecasting can improve planning accuracy, streamline inventory management, and enhance operational efficiency. At the same time, greater supply chain visibility enables organizations to respond more effectively to disruptions, improve product availability, and deliver higher levels of customer service. Digital tools also play a critical role in strengthening compliance and audit readiness, particularly in a sector governed by stringent safety and documentation requirements.

Beyond individual firm-level benefits, digital integration is improving coordination across the broader ecosystem-linking manufacturers, logistics providers, ports, and regulatory authorities onto unified platforms. This reduces inefficiencies associated with siloed operations and fragmented data flows, enabling smoother execution of logistics processes and regulatory compliance.

However, a key challenge remains in translating digital intent into scalable outcomes. While investment momentum is strong, the effectiveness of digital transformation might depend on the ability to integrate disparate systems, ensure data interoperability, and embed digital capabilities into core operational workflows.

In aggregate, the convergence of policy-led digital infrastructure (ULIP, NLP) and enterprise-level technology adoption is fundamentally reshaping India's chemical supply chains. By enabling real-time visibility, predictive decision-making, and faster operational response, digital capabilities are helping the sector transition from reactive, fragmented operations to integrated, resilient, and intelligence-driven networks-well aligned with the scale, complexity, and risk profile of modern chemical logistics.

36. World Bank Logistics Performance Index (2023);
37. Government of India, Press Information Bureau (2023–2024); Ministry of Ports, Shipping & Waterways statistics on turnaround time

Regulatory harmonization

Regulatory harmonization represents one of the most complex yet strategically important levers for strengthening supply chain resilience and enhancing India's global competitiveness in the chemical sector. While India has a well-developed regulatory architecture governing safety, environmental protection, and chemical handling, which involves coordination across multiple central and state authorities. This can influence approval timelines and compliance processes costs against global standards.

At its core, regulatory harmonization is essential to enable scale, efficiency, and international market access. A critical step in this direction is the development of the Chemicals Management and Safety Rules (CMSR, or India-REACH), which aims to:

Align India's chemical safety framework with global standards such as GHS and REACH

Establish a unified national chemical database

Improve transparency, traceability, and compliance monitoring across value chains

Reform Sequencing

1	Finalize and phase CMSR Implementation Align with international chemical safety frameworks, maintain industry feasibility
2	Single window clearance in Chemical Parks Enable plug-and-play investment; reduce approval timelines
3	Digitize & standardize compliance processes Unified digital platform for hazardous material documentation across states
4	Adopt risk-based regulatory model Stringent for high-risk segments, simplified for low-risk; preserve export credibility

The adoption of a risk-based regulatory model is particularly critical. Rather than uniformly relaxing standards, India must maintain high stringency in areas such as hazardous chemicals, environmental impact, and safety compliance, while accelerating approvals for lower-risk categories through differentiated pathways. This approach ensures that regulatory credibility-critical for export markets-is preserved, while improving ease of doing business.

From a strategic perspective, strong and globally aligned regulatory frameworks are increasingly a prerequisite for participation in international supply chains. Export markets-particularly in Europe and North America-require adherence to standards such as REACH, GHS, and IMDG, alongside growing expectations around ESG compliance and traceability. In this context, regulatory alignment is not merely a compliance requirement but a market access enabler.

Encouragingly, recent policy measures-including the development of dedicated Chemical Parks, initiatives under GatiShakti, and the push toward digital integration-signal progress toward greater regulatory coordination. However, the next phase of reform must focus on execution, particularly in reducing time-to-approval and improving system-wide efficiency.

Ultimately, India's regulatory competitiveness might depend not on lowering standards but on improving the speed and predictability of regulatory processes. The shift required is from a perceived trade-off between "stringency versus speed" to a model of "stringency with efficiency." Achieving this balance might be critical to positioning India as a trusted, compliant, and globally competitive hub within the evolving chemical supply chain landscape.

India's chemical supply chain resilience challenge is not one of capability but of execution. The structural gaps-in infrastructure, feedstock security, and regulatory coherence-are well understood and increasingly being addressed through targeted interventions. The pace at which these reforms are implemented might determine whether India can convert its current geopolitical advantage into lasting global leadership in chemical supply chains.


Hazardous Chemical and Material Classes
Safety Checklist Form
CLASS 1-Explosives
CLASS 2-Gases
CLASS 3-Flammable liquids
CLASS 4-Flammable solids
CLASS 5-Oxidizers
CLASS 6-Toxic materials
CLASS 7-Radioactive materials
CLASS 8-Corrosive materials
CLASS 9-Miscellaneous dangerous goods
DANGEROUS- Indicates a mixed load of hazardous materials

03

Designing for tomorrow: The intelligent, adaptive supply chain

Designing for tomorrow: The intelligent, adaptive supply chain

The chemical industry stands at a profound inflection point. Decades of optimization built on linear, efficiency-first supply chain architectures are being rendered obsolete - not by incremental disruption, but by a fundamental restructuring of what supply chains must do. They must no longer merely move molecules from source to customer. They must sense, interpret, decide, and adapt in real time, at scale, across an increasingly fragmented and volatile global landscape. The gap between the opportunity and the current state is both the challenge and the mandate for chemical industry leaders

From linear chains to intelligent networks

The chemical industry built its supply chain architecture for a world of stable trade routes, predictable feedstock economics, and periodic - not perennial - disruption. That world ended. The Red Sea crisis alone saw container ship transits through the Suez Canal fall 75 per cent by end of 2024[38], rerouting vessels around the Cape of Good Hope and adding 10–14 days transit time with sustained freight premiums. Simultaneously, the Panama Canal - the second critical chokepoint for Asia–U.S. chemical flows - recorded a 21 per cent reduction[39] in deep-draft vessel transits in FY2024 due to one of the most severe drought in the canal's recorded history. For chemical manufacturers, whose product margins are measured in single-digit percentages, this is a structural cost shock.

The intelligent chemical supply network is built on four principles with an architecture specifically designed for the chemical industry's hazmat compliance requirements, feedstock volatility dynamics, specialty-commodity product divergence, and the concentrated chokepoint risks.

Continuous sensing:
A chemical supply chain cannot adapt to what it cannot see. Continuous sensing builds a multi-layered real-time information environment: IoT sensors on chemical tankers, production assets and logistics fleets; AIS vessel tracking feeds integrated with port congestion data; feedstock forward curves for ethylene, propylene, benzene and methanol; LIMS quality signals from production lines; and geopolitical event streams. Unlike generic supply chains, chemical sensing must extend to IMDG classification databases, REACH substance registration status, and Responsible Care incident feeds - because a quality event in a chemical plant is a supply disruption before it becomes a logistics problem.

Distributed decisions
The chemical industry's planning processes were built for a stable world: weekly S&OP meetings, monthly procurement reviews, quarterly network assessments. When the Red Sea crisis hit in late 2023, companies discovered that their organizational decision cycles were measured in days - and the optimal response window closed in hours. Distributed decision-making moves authority to the point of impact. Routine operational decisions - logistics rerouting within hazmat compliance guardrails, replenishment triggers, carrier fallback activation - are executed autonomously within defined parameters. Human judgement is reserved for commercial trade-offs, novel scenarios, and decisions with significant regulatory or relational implications.

Integrated intelligence
Sensing data only creates value when it generates a unified operational picture across functions and tiers. many chemical companies manage ERP, LIMS, TMS, and WMS as separate information silos. Integrated intelligence connects these through a common cloud-hosted data layer with standardised chemical data models: CAS number-based product identifiers, batch-level quality schemas, REACH/TSCA compliance status, and hazmat classification codes. The result is a single version of truth that eliminates the 'telephone game' of cross-functional escalation where information degrades at every handoff between procurement, manufacturing, logistics, and commercial teams.

Adaptive response
The defining characteristic of the intelligent network is its capacity to adapt - to reconfigure itself in response to changing conditions rather than reverting to a pre-defined steady state. This adaptive capacity operates across three-time horizons: tactical adaptation in hours (rerouting shipments, activating buffer stocks); operational adaptation in days and weeks (shifting production across sites, qualifying alternate feedstock grades); and strategic adaptation in months and quarters (network topology redesign, long-term sourcing restructuring). Critically, network design decisions in chemical supply chains must be evaluated not only on average-case economics but on their contribution to adaptive range - the breadth of disruption scenarios the network can absorb without service failure.

38.The Deepening Red Sea Shipping Crisis: Impacts, World Bank, February 2025
39. Panama Canal Financial Report FY24

Linear chain vs. Intelligent network: the architectural contrast

How information flow, decision-making, and disruption response differ structurally between the two models

Linear supply chain (Old model)

Sequential, Siloed, Reactive

- Information flows unidirectionally: supplier → manufacturer → distributor → customer
- Each node optimizes locally with no visibility of upstream or downstream state
- Decisions made by humans reviewing data that is hours or days old
- Disruptions propagate downstream before detection: bullwhip effect amplifies shocks
- Only a few organizations have full end-to-end supply chain visibility
- A high per cent of supply chain professionals cite insufficient visibility as their primary challenge
- A high per cent of compliance teams spend 11+ hours per week on manual data translation[4]
- Performance measured by cost and on-time delivery: carbon and resilience invisible

Intelligent network (new model)

Concurrent, Connected, Autonomous

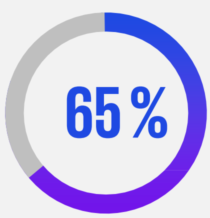
- Information flows multi-directionally in real time across all nodes simultaneously
- Each node has full network visibility and can act on shared intelligence
- Agentic AI makes and executes routine decisions autonomously: humans govern exceptions
- Disruptions are detected and absorbed before propagating: self-healing architecture
- Decision latency reduced from days to seconds through autonomous AI agents
- Digital twins simulate disruption scenarios before they occur: proactive not reactive
- Scope 1/2/3 emissions intelligence embedded in every logistics decision
- Performance scorecard integrates cost, carbon, resilience, and customer value

AI-first supply chains

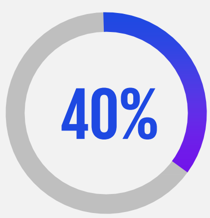
AI in the chemical supply chain is not a generic efficiency play. It is the mechanism by which chemical companies can finally operationalize the complex, multi-variable optimization problems that have always existed in the sector but that manual planning processes could never solve in real time: simultaneous optimization of feedstock cost versus availability versus quality versus logistics risk versus regulatory compliance, across dozens of product lines and geographies, with decisions that need to be made in hours, not weeks.

The evidence base is now concrete.

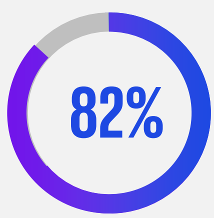
KPMG 2025 Global ENRC CEO Outlook



CEOs rank generative AI as a top investment area



CEOs are reskilling and upskilling roles impacted by AI



CEOs believe AI can support emissions reduction and energy efficiency.

The gap between chemical companies that have begun this transformation and those that have not is already measurable in logistics costs, downtime rates, and supply chain responsiveness.

Control towers and real time visibility

A chemical industry control tower is architecturally distinct from generic supply chain control towers in several critical dimensions. It must integrate hazardous materials compliance data in real time - because rerouting a chemical shipment is not just a logistics decision; it is a regulatory event requiring IMDG/ADR re-documentation. It must monitor chemical-specific freight markets: chemical tanker and liquid bulk rates, which trade on entirely different dynamics from dry container shipping. And it must integrate LIMS quality data, because in chemical manufacturing, a quality excursion at a production facility is a supply disruption before it manifests as a logistics problem.

Chemical industry control tower: Five intelligence domains

Feedstock intelligence

Chemical-specific: feedstock costs represent 60–70 per cent[40] of variable cost in commodity chemicals

Chemical logistics intelligence

Chemical-specific: IMDG/ADR compliance embedded in logistics decisions

Production and quality intelligence

batch genealogy required for customer traceability and regulatory compliance

Demand intelligence

Specialty and commodity chemicals have fundamentally different demand volatility profiles

Regulatory and safety intelligence

Regulatory non-compliance can halt production or shipment immediately

40. Company press release

Agentic AI and autonomous decision-making through S&OP

The chemical industry's S&OP process has a complexity dimension that distinguishes it from other sectors: it must simultaneously balance feedstock procurement (where price volatility is extreme and forward purchasing carries balance sheet risk), production scheduling (where batch sizes, campaign lengths, and reactor changeover costs are high), quality-controlled finished goods inventory (where off-spec product cannot simply be discounted and sold), and hazmat-compliant logistics (where rerouting has regulatory, not just commercial, consequences).

A major chemical manufacturer has deployed GenAI for supply chain resilience and scenario planning - modelling disruption scenarios and proposing optimized responses including alternative sourcing, logistics rerouting, and demand adjustments. Middle East petrochemicals giant has implemented AI-driven scenario planning tools specifically for supply chain disruption forecasting and response[41]. These represent early manifestations of the agentic AI model that might define chemical supply chain management by 2030.

Three-layer S&OP Architecture: Chemical industry application

- **Layer 1 operation continuous:** This layer governs day-to-day execution activities such as logistics rerouting within hazmat compliance guardrails, quality hold notifications, strategic buffer stock replenishment, carrier fallback activation, and ISO tank repositioning. AI operates with high autonomy within defined regulatory boundaries, while humans focus on exception management, governance, and compliance oversight.

  High AI autonomy within defined regulatory guardrails.

  Human oversight role is limited to exception review and guardrail governance

- **Layer 2 tactical weekly:** This layer supports short-term planning decisions including feedstock spot-versus-contract balancing, constrained capacity allocation across product grades, contingency supplier activation, off-spec product disposition, and customer priority resequencing. AI generates recommendations and evaluates trade-offs, while human planners apply commercial judgement, manage customer relationships, and balance margin against service commitments.

  Moderate AI Autonomy wherein AI recommends, and human approves.

- **Layer 3 strategic/monthly** : This layer addresses long-term decisions such as resilience investments, feedstock supply contracting, network topology redesign, regional distribution footprint optimization, and product portfolio rationalization. AI contributes scenario analysis, financial modelling, and risk quantification, while leadership retains full ownership of strategic decision-making and enterprise direction.

  Low AI autonomy wherein AI provides scenario and humans decide

  Humans lead all strategic decisions, AI delivers scenario analysis and risk quantification

41. Corporate, Information and Cybersecurity, BASF’s 2023 annual report, February 2024

Scenario simulation and digital twins at scale

Digital twin technology is reshaping chemical industry supply chain management from a domain that was historically reactive and opaque to one that is predictive, transparent, and - increasingly - autonomous. The chemical sector has specific digital twin requirements that go beyond generic supply chain models: the twin must replicate chemical reaction kinetics, heat and mass transfer dynamics, process safety parameters, and batch genealogy - not merely inventory positions and lead times.

A European chemical player implemented a digital twin via AVEVA's CAE system, integrating data from ERP, plant breakdown structure, document management, and IIoT systems. The twin began with specific production lines, simulating chemical reactions and optimizing process parameters, eventually enabling dynamic adjustments based on real-time sensor data across processes. Another chemical major’s digital twin detects deviations from quality specifications in real time, enabling corrective actions that ensure consistent product quality and regulatory compliance while simultaneously optimizing supply chain inventory and lead times.

Scenario simulation delivers

Scenario simulation using digital twins answers the questions that traditional planning systems cannot: What happens to service levels if our primary propylene supplier is unavailable for 45 days? What is the working capital impact of shifting to a triple-source feedstock strategy? In the chemical industry, these questions have always been important but were impossible to answer quickly enough to inform decisions. Digital twins answer them in hours, not weeks, with the full chemical-sector complexity - batch constraints, hazmat handling rules, LIMS quality requirements, and compliance documentation - embedded in the model.

Three high-value scenario simulation applications in chemicals

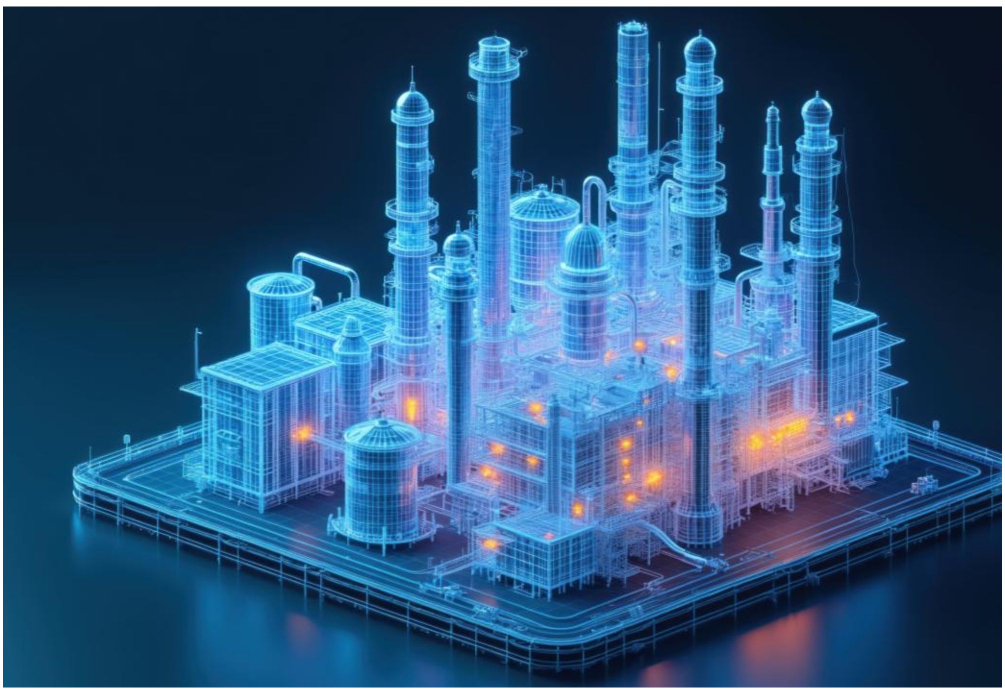
Disruption Response Design: Plan for supplier disruption and rerouting

Network Redesign Evaluation: Test new plant or distribution network options

Trade and Tariff Scenario Modelling: Model trade tariffs and sourcing cost impacts

Digital twins at scale: The emerging frontier

Several advanced implementations are moving beyond periodic simulation to real-time digital twins - models continuously synchronized with actual supply chain conditions. Chemical companies deploying Agentic AI + LLM integration with digital twin technology are creating systems that can proactively reason, plan and act: simulating outcomes before executing decisions, and autonomously managing supply chain disruptions within defined regulatory guardrails. This represents the convergence of digital twin and agentic AI - Level 4 maturity in the chemical industry’s digital transformation journey



The future operating model

The technology architecture described in the previous sections requires an organizational model capable of deploying and sustaining it. The chemical industry faces a particularly acute version of the talent and operating model challenge: it is navigating a digital transformation of profound complexity at the same moment that its workforce is undergoing a generational transition of historic scale.

Platform-based chemical supply chains

Platform-based supply chains in chemicals share data across three layers. The Data Platform establishes common chemical data standards: CAS number-based product identifiers, batch-level quality data schemas, REACH/TSCA compliance status feeds, and hazmat classification codes. The Process Platform standardizes chemical logistics workflows: CoA exchange, IMDG documentation, SDS distribution, and regulatory reporting. The Intelligence Platform runs AI-powered feedstock procurement optimization, demand sensing, and multi-tier supplier risk monitoring - capabilities that no individual chemical company can build effectively in isolation.

The self-healing chemical supply chain

The self-healing chemical supply chain responds to disruption before it reaches the customer - autonomously, within regulatory guardrails, at a speed that manual escalation processes cannot match. Its chemical-industry-specific requirements include: automated hazmat compliance re-documentation when rerouting is triggered; pre-cleared alternative feedstock grade qualification for autonomous substitution decisions; and integration with the Responsible Care Management System for safety event response.

The self-healing supply chain: capability stack and deployment timeline

Technology layers that compose a self-healing intelligent network from data foundation to autonomous action

LAYER 5: AUTONOMOUS	Agentic AI Decision Execution; Self-Correcting S&OP Cycles; Autonomous carrier Booking; Dynamic Inventory Rebalancing; Carbon – Optimized Mode Selection
LAYER 4: SIMULATION	Supply Chain Digital Twins; Disruption Scenario Modelling; Network Resilience Stress-Testing; What-If Carbon Impact Analysis
LAYER 3: INTELLIGENCE	AI Demand Forecasting; Predictive Risk Analytics; GenAI S&OP Recommendations; Geopolitical Signal Processing; Scope 1/2/3 Emissions Intelligence
LAYER 2: VISIBILITY	Control Tower Platform; IoT Sensor Networks; Real-Time Freight Intelligence; Multi-Party Visibility Networks; Blockchain Track& Trace
LAYER 1: FOUNDATION	Unified Data Platform (Cloud); Master Data; Governance, ERP/WMS/TMS Integration; API-First Architecture

Many chemical companies have invested in Layers 1-2 but have not completed the data governance required to deploy Layers 3-4 at enterprise scale. The inability to progress from visibility to intelligence is the defining bottleneck of the industry's digital transformation.

Ecosystem partnerships and data sharing

Chemical industry ecosystem partnerships take many distinct forms, addressing a different dimension of the intelligence gap. Technology ecosystem partnerships with platform providers give chemical companies access to sensing, analytics, and AI capabilities that might be prohibitively expensive to build internally. Supplier development partnerships invest in the data infrastructure of Tier 1 and Tier 2 suppliers, because the quality of supply chain intelligence is bounded by the quality of data flowing from the supply base. And coopetition arrangements - selective data sharing among competitors on non-competitive supply chain challenges - address problems too large and systemic for any individual company to solve alone.

Talent transformation and digital capabilities

The future operating model requires chemical companies to build talent and digital capabilities across four interconnected imperatives simultaneously. With significant per cent of the chemical workforce eligible to retire within five years and an entirely new category of digital-chemistry hybrid roles emerging - roles that barely existed as defined skill sets in 2020 - the workforce architecture of the future supply chain must be designed proactively, not assembled reactively. Companies that build this capability infrastructure ahead of the curve might gain access to talent and institutional knowledge their competitors might find impossible to acquire or replicate.

Four operating model imperatives for talent and digital capability

- **Institutional Knowledge Preservation:** Capture and share retiring experts' process knowledge
- **Hybrid Technical–Digital Capability Development:** Build combined chemistry, digital and AI skills
- **Building the Digital Supply Chain Workforce of the Future:** Create new digital supply chain roles early
- **Broadening the Talent Sourcing Model:** Expand hiring beyond traditional industry talent pools

04

Strategic playbook: Winning in a decade of uncertainty

Strategic playbook: Winning in a decade of uncertainty

In this new terrain: a world that is structurally, not cyclically, different; an Indian chemical logistics ecosystem caught between acute operational pressure and historic strategic opportunity; and a set of intelligent, autonomous technologies that are beginning to reshape how supply chains sense, decide, and act. Here are five interconnected imperatives that, taken together, define what a winning chemical supply chain organization looks like across the decade to 2030. These are not incremental performance improvements. They are a fundamental reconception of how chemical supply chains are designed, governed, and competed upon.

The five imperatives for chemical leaders

01 Resilience by Design	02 Sustainability at Scale	03 Digital-First Operating Models	04 Ecosystem Partnerships	05 Policy Alignment
From reactive crisis management to autonomous, self-healing supply chain architecture	From compliance burden to commercial advantage and margin resilience through decarbonization	From pilot-stage experimentation to enterprise-scale AI that drives measurable outcomes	From transactional vendor relationships to co-innovation partnerships that create structural advantage	From reactive compliance to proactive policy engagement as a first-mover competitive lever

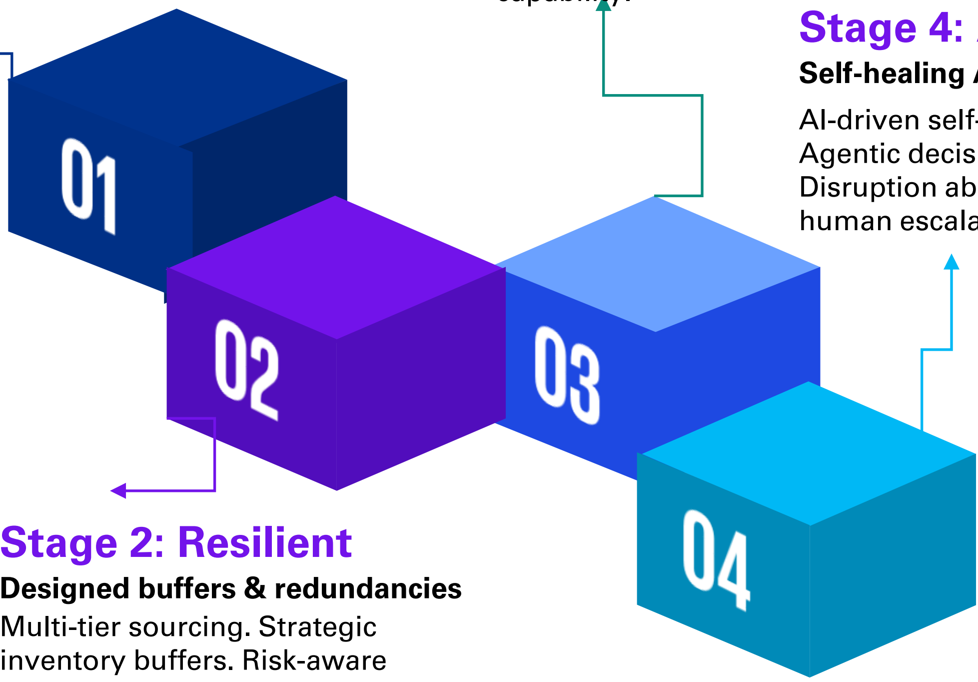
These imperatives are not independent choices. They are deeply interdependent - resilience creates the stability required for sustainability investment; sustainability mandates accelerate digital adoption; digital intelligence enables ecosystem collaboration; and all four are anchored by proactive policy alignment. Organizations that pursue them as a cohesive, sequenced transformation program might emerge structurally differentiated.

01: Resilience by design

Building supply chains that survive disruption

One of the most revealing characteristic of how chemical supply chains have been managed over the past decade is not what they did during crises - it is how quickly the same crises exposed the same structural vulnerabilities, again and again. The recent global disruptions were treated as a novel event requiring an emergency response. The responses consumed enormous management bandwidth, generated significant cost overruns, and ultimately resolved itself not through strategic capability but through the crisis passing. This is the defining characteristic of a *reactive* supply chain: one that is fundamentally designed for a stable world and surprised by deviation from it.

The strategic imperative of this decade is to move decisively through a four-stage maturity journey. The destination - the *autonomous* supply chain - is not a destination that many chemical organizations might reach by 2030. But the trajectory of that journey, and the pace at which organizations move along it, might be the determinant of competitive positioning across the next decade. Organizations that remain at the reactive stage while peers advance to adaptive or autonomous might face a structural disadvantage that cannot be overcome by operational efficiency alone.



Stage 1: Reactive

Crisis-driven response only

Single-source dependencies. No buffer stock strategy. Disruption = crisis.

Stage 2: Resilient

Designed buffers & redundancies

Multi-tier sourcing. Strategic inventory buffers. Risk-aware network design.

Stage 3: Adaptive

Predictive and scenario-proofed

Scenario planning embedded. Digital risk monitoring. Real-time rerouting capability.

Stage 4: Autonomous

Self-healing AI-driven

AI-driven self-correction. Agentic decision-making. Disruption absorbed without human escalation.

The transition from **Stage 1 (Reactive)** to **Stage 2 (Resilient)** is an urgent near-term requirement for Indian chemical companies, the majority of which remain structurally reactive[42]. The foundational capabilities of a resilient supply chain - multi-tier supplier networks, strategic buffer inventory, geographic sourcing diversification, and robust business continuity plans - are well understood but unevenly implemented. What the recent disruptions of 2024–26 demonstrated is that even organizations that believed they had adequate resilience were caught by the speed and simultaneity of the shocks. Building Stage 2 resilience requires deliberate investment in redundancy that might appear wasteful during stable periods - a difficult argument to make to finance leadership - but whose value is measured precisely in the moments when competitors are scrambling, and resilient organizations are delivering.

The transition from **Stage 2 (Resilient)** to **Stage 3 (Adaptive)** requires the integration of digital intelligence into supply chain decision-making - not as a monitoring layer, but as a predictive and scenario-simulation capability. An adaptive supply chain does not merely absorb shocks; it anticipates them. It uses real-time geopolitical intelligence, freight market signals, and scenario-modelling frameworks to adjust routing, sourcing, and inventory positioning before disruption arrives - not after. This is where the chemical industry's digital transformation investment must deliver practical, operational value, rather than remaining confined to corporate dashboards and sustainability reports.

42. KPMG in India 2026 analysis

Case study: Eastman Chemical: Embedding AI-driven resilience into supply chain operations

Eastman Chemical has deployed Generative AI across its supply chain analytics and risk monitoring infrastructure, creating a capability that provides real-time threat detection and operational insights across its global chemical supply network. This places the company firmly at Stage 3 of the resilience maturity: predictive, not reactive.

The journey to **Stage 4 (Autonomous)** - where AI-driven systems make and execute supply chain decisions with minimal human escalation - is a 2028–2035 horizon for many organizations. But the architectural decisions made between 2026 and 2028 might determine which organizations are positioned to reach it. Specifically, data governance frameworks, AI model training datasets, and the cultural willingness to trust machine-generated decisions in high-stakes chemical logistics environments must all be developed now - because they cannot be retrofitted onto an autonomous system after the fact. The organizations that reach Stage 4 might hold a structural, sustainable competitive advantage that that may be difficult to replicate.

02: Sustainability at scale: From compliance cost to commercial advantage

Making decarbonization a source of margin, customer loyalty and financing advantage

The chemical industry occupies a paradoxical position in the global decarbonization agenda. It is, simultaneously, one of the largest industrial energy consumer, source of industrial greenhouse gas emissions globally, and the provider of inputs for almost all manufactured goods - including the majority of the technologies upon which the energy transition itself depends. This paradox defines the sustainability challenge: chemical companies cannot simply decarbonize by exiting fossil fuel inputs without disrupting the very systems they supply. The transition must be managed with precision across a complex, multi-tier value chain.

What has changed fundamentally in 2025–26 is the commercial framing of that challenge. For most of the past decade, sustainability investments in the chemical supply chain were evaluated purely through the lens of cost and regulatory compliance. That framing is no longer commercially accurate. Many sophisticated chemical supply chain organizations - and the financial institutions that finance them - have recognized that embedded decarbonisation initiatives, when structurally designed, deliver three commercially valuable outcomes simultaneously: they reduce logistics costs through fuel efficiency and modal optimization; they deepen customer relationships by enabling customers to meet their own Scope 3 commitments; and they unlock access to green financing instruments at materially lower cost of capital than conventional debt.

GBP800 Mn
Estimated annual cost to UK businesses from EU Carbon Border Adjustment Mechanism - signaling the financial cost of inaction on Scope 3

USD107 Bn
Global insurance losses from natural catastrophes in 2025 - making physical climate risk a direct chemical logistics cost factor

43. Microsoft, UK Government, Swiss Re

The Science Based Targets initiative (SBTi) published its first detailed decarbonisation pathways specifically for the chemical industry in late 2025 - providing, a scientifically rigorous framework that chemical companies can use to set credible net-zero targets and communicate progress transparently to investors, customers, and regulators. The significance of this development is substantial as it removes the measurement uncertainty excuse that has historically been used to defer sustainability action and creates a common language that enables direct comparison of decarbonization performance across organizations. Chemical companies that are not aligned with SBTi pathways by 2027 might face increasing pressure from institutional investors, major customers with their own Scope 3 reduction obligations, and regulators implementing Carbon Border Adjustment Mechanisms in key export markets.

Case study: BASF's PACIFIC platform: Blockchain-enabled product carbon footprint transparency

BASF has deployed its PACIFIC blockchain platform to enable transparent, verifiable exchange of Product Carbon Footprint (PCF) data across its chemical supply chain, allowing end-to-end carbon tracking and supporting Scope 3 accountability. This creates a differentiated commercial advantage by embedding sustainability into customer decisions and enabling premium positioning. In parallel, BASF has secured long-term supply of chemically recycled benzene through Encina, reinforcing circular feedstock sourcing and enabling lower lifecycle carbon products.

For Indian chemical companies, the sustainability imperative has a specifically strategic dimension that extends beyond the global decarbonization agenda. India's chemical export competitiveness in the European market - one of the highest-value and fastest-growing destinations for Indian specialty chemicals - might be directly affected by the EU's Carbon Border Adjustment Mechanism (CBAM), which is progressively tightening its scope to include chemical products. Indian chemical manufacturers that do not build credible, verifiable Scope 1/2/3 carbon accounting capabilities risk facing cost penalties at European borders that undermine the price competitiveness that has historically been their primary differentiator. The window to build this infrastructure ahead of the competitive impact is 2026 to 2028 - and it is closing.

03: Digital-first operating models: From pilot to profit

Converting digital investment into enterprise-scale operational and commercial results

The chemical industry's digital journey has largely been marked by a gap between investment and impact -despite significant spending on AI, IoT, digital twins, and analytics, many initiatives have not scaled beyond pilots or delivered enterprise-wide value.

THE DIGITAL MATURITY DIAGNOSIS: WHY MANY CHEMICAL COMPANIES ARE STUCK

1

The pilot trap: Many chemical organizations run multiple digital pilots with limited integration into core operations and no clear path to scale, evaluating success on technical performance rather than operational or commercial impact.

2

The data governance deficit: AI systems are only as good as the data they are trained on. Many chemical supply chains operate across fragmented, non-standardized data environments - different ERP instances, inconsistent data definitions across business units, and poor-quality master data. These conditions make it effectively impossible to train AI models that deliver reliable, enterprise-scale results.

3

The cultural resistance barrier: In high-stakes, regulated chemical logistics environments, there is deep cultural reluctance to trust machine-generated decisions - particularly for routing hazardous materials, managing safety-critical inventory thresholds, and making commercial commitments to customers. This resistance reflects governance gaps that must be addressed before autonomous decision-making can be expanded.

44. Science Based Targets initiative (SBTi), BASF, HFS Research

The diagnosis for this underperformance is consistent across the industry and well-evidenced: digital investment has been treated as an innovation project rather than as operational infrastructure. One of the most commercially impactful deployments of AI and digital technology in chemical supply chains share a common characteristic - they were integrated directly into day-to-day operational decision-making, with clear accountability for outcomes, rather than being maintained as parallel systems that inform but do not govern core processes. The imperative for the next decade is to make the transition from digital investment to digital infrastructure - embedding AI and data intelligence into the operational fabric of the supply chain, not alongside it.

76 per cent

Share of chemical companies now using AI to optimize production processes - signaling broad adoption but uneven depth of impact

6-14 per cent

AI's projected contribution to chemical company revenue: 6 per cent in 2025 growing to 14 per cent by 2028 - USD800 Mn opportunity for a USD10 Bn company[45]

One of the most consequential digital capability for chemical supply chains over the next decade is not a specific technology platform - it is the combination of agentic AI and digital twin simulation operating within a unified control tower architecture. Agentic AI - systems that can initiate and execute multi-step operational decisions with defined parameters, without requiring human approval for each step - represents the pathway to Stage 4 autonomous supply chain management. Digital twin simulation enables organizations to stress-test their supply networks against disruption scenarios before those disruptions occur, rather than discovering vulnerabilities in real time. The integration of these two capabilities within a control tower that provides genuine end-to-end visibility - not siloed departmental dashboards - creates the operating architecture of the adaptive and autonomous supply chain.

For Indian chemical companies, where the technology investment gap relative to global majors is significant, the strategic opportunity is to leapfrog incremental technology adoption and invest directly in integrated, AI-native supply chain platforms - rather than layering digital tools onto legacy ERP and planning systems that might constrain their effectiveness. The cost of building on a clean architectural foundation is lower than the cost of retrofitting intelligence onto a fragmented legacy landscape. The window for this architectural decision is now.

45. Company annual report, Global Lancers, SmartDev, IBM Research

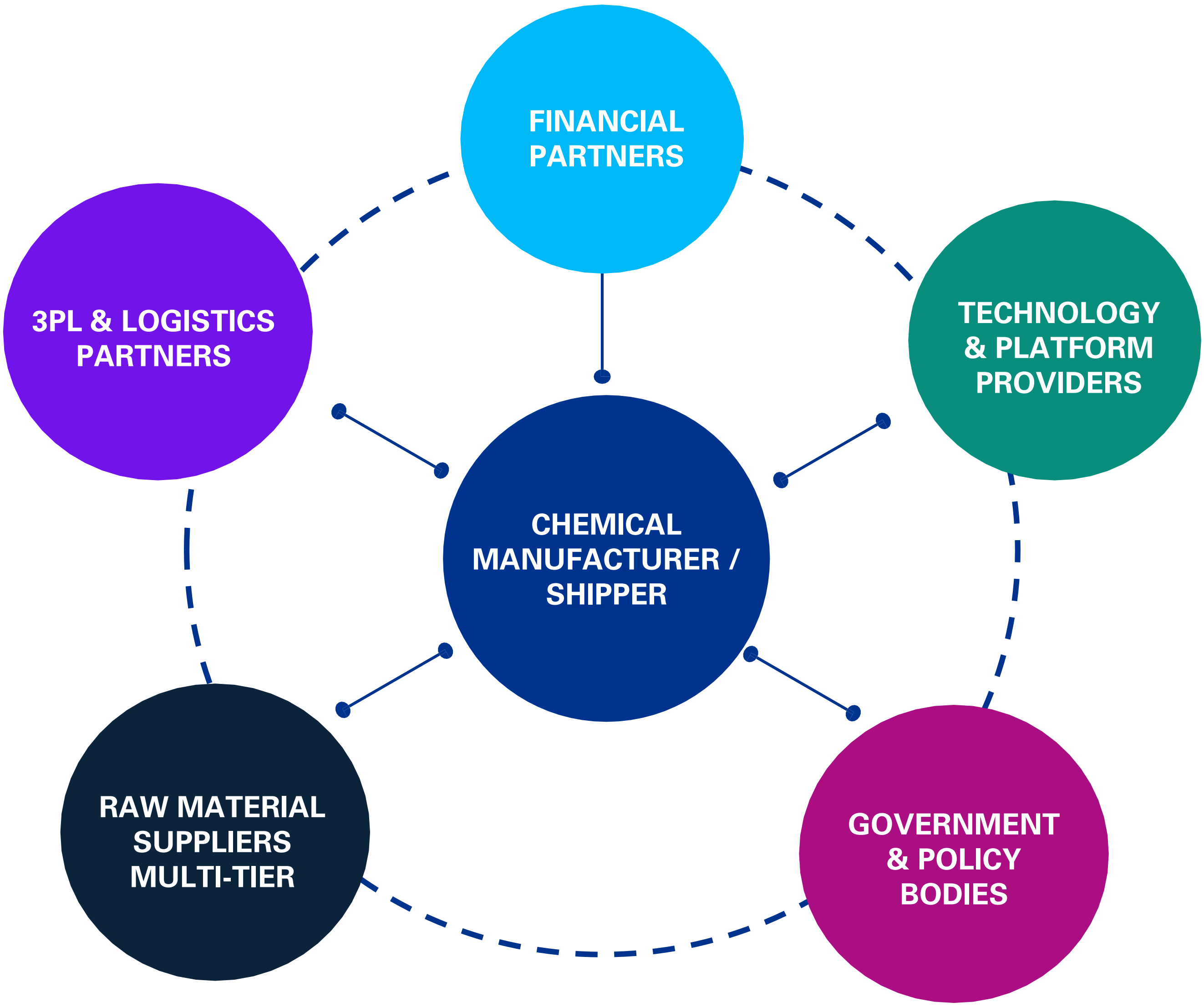
04: Ecosystem partnerships: From transactional to transformational

Building the collaborative architectures that no single organization can build alone

The supply chain transformations share a critical characteristic: none can be fully achieved by a single organization acting alone. A chemical manufacturer cannot decarb its logistics without 3PL partners who are committed to the same fuel transition. It cannot achieve real-time end-to-end supply chain visibility without technology partners whose platforms integrate across enterprise boundaries. It cannot build multi-tier supplier resilience without those suppliers themselves investing in their own digital and operational capabilities. The era of treating logistics providers, technology companies, and supply chain partners as interchangeable, cost-optimized vendors is over. The next decade demands a fundamentally different partnership model - one built on co-investment, shared data, aligned incentives, and mutual commitment to transformation outcomes.

The chemical supply chain ecosystem partnership architecture

The winning chemical supply chain organization sits at the center of a tightly integrated, data-sharing ecosystem - not at the top of a linear vendor hierarchy.



46. KPMG in India 2026 analysis

What distinguishes many commercially effective ecosystem partnerships from transactional vendor relationships is the depth of strategic alignment and the willingness to share value - and risk - across organizational boundaries. In the chemical industry, this manifests in three distinct partnership archetypes, each representing a qualitatively different level of ecosystem integration.

Co-investment partnerships

Involves chemical manufacturers and logistics providers jointly investing in infrastructure, technology, or capabilities, sharing both costs and benefits. For example, Dow-Freepoint partnership[47] for chemical recycling infrastructure. In India, such partnerships, especially in dedicated chemical warehousing and hazardous logistics, represent a high-potential near-term opportunity.

Data-sharing partnerships

Involves chemical manufacturers, logistics providers, and technology platforms building shared data infrastructure to enable collective supply chain intelligence. For example, BASF's PACIFIC platform[48] allows verified PCF data exchange, creating shared value by supporting customer Scope 3 reporting, optimizing logistics operations, and enabling regulatory compliance through a single governed system.

Innovation co-creation partnerships

Involves chemical companies jointly developing solutions with startups, technology providers, and research institutions rather than procuring off-the-shelf offerings. Increasingly adopted in global markets and emerging in India, this model enables ecosystem-led innovation, which is critical for scaling sustainability investments that individual players cannot fund or de-risk alone.

05: Policy alignment: From reactive compliance to first-mover advantage

Converting the policy environment from a threat to be managed into a competitive lever to be wielded

The relationship between the chemical supply chain industry and the policy environment has historically been adversarial in character: regulation arrives as an external imposition; compliance is managed as a cost; and the goal is to minimize the operational disruption of the latest mandate while awaiting the next one.

This posture - understandable in a world where regulatory change was episodic and manageable - is now commercially dangerous. The pace and breadth of policy change affecting chemical supply chains has accelerated dramatically: emissions reporting mandates, carbon border adjustment mechanisms, ESG disclosure requirements, dangerous goods transportation standards, digital product passport requirements, and trade tariff structures are all evolving simultaneously, across multiple jurisdictions, on compressed timelines.

Organizations that react to regulations after they take effect face a structural cost disadvantage versus those that align early. Proactive alignment builds trust, lowers compliance costs, unlocks early access to incentives (e.g., PLIs, FTAs, green subsidies), and enables influence over policy design.

47. Dow, 2026
48. BASF, 2026

Key takeaways

The global chemical supply chain is entering a defining period of transformation, shaped by geopolitical fragmentation, climate disruptions, input cost volatility, sustainability expectations, and rapid digitalization. What was earlier treated as episodic disruption has now become a structural feature of the operating environment. Chemical companies might need to redesign their networks around resilience, optionality, visibility, and speed of response, while continuing to remain cost competitive.

India has a clear strategic opening in this reconfigured global landscape. As companies move from concentrated global supply models toward diversified and regional networks, India can position itself as a reliable supply chain anchor for chemicals. However, India's advantage cannot rest only on domestic demand, cost competitiveness, or policy intent. The real differentiator is expected to be the country's ability to provide dependable supply, integrated ecosystems, global quality standards, regulatory confidence, and logistics reliability at scale.

The immediate resilience agenda for India is practical and execution focused. Reducing dependence on imported feedstocks and intermediates, expanding backward integration, developing port linked chemical clusters, diversifying supplier geographies, and creating strategic stockpiles for critical inputs expected to be essential. These measures are not only defensive, but they can also improve export competitiveness, stabilize margins, and strengthen India's credibility as a supplier in volatile global markets.

Infrastructure is expected to be a decisive enabler, but the requirement is chemical specific. General logistics improvement might not be sufficient for a sector that depends on safe handling, storage, compliance documentation, temperature sensitivity, hazardous cargo movement, and port efficiency. India's progress on logistics costs, port turnaround, multimodal infrastructure, and digital logistics platforms must now be complemented by dedicated hazardous material corridors, specialized warehousing, reliable last mile connectivity, and stronger integration between chemical clusters and ports.

The future chemical supply chain is expected to be intelligent by design. AI, control towers, digital twins, real time freight intelligence, IoT tracking, blockchain traceability, and agentic decision systems expected to move supply chains from monitoring to prediction, and from prediction to autonomous response. Companies that integrate these technologies into operating decisions, rather than running them as pilots, expected to be better placed to manage disruption, optimize inventory, improve service levels, and strengthen compliance.

Sustainability is becoming a source of strategic advantage, not only a compliance obligation. Scope 3 emissions visibility, carbon aware logistics, circular feedstocks, green freight choices, and verifiable product carbon data expected to increasingly influence customer selection, financing access, and export competitiveness. For Indian chemical companies, this capability is expected to be particularly important as global markets tighten expectations around carbon, traceability, responsible sourcing, and ESG disclosure

No single organization can build the next generation chemical supply chain alone. The report highlights the need for ecosystem partnerships across manufacturers, logistics providers, technology platforms, raw material suppliers, policymakers, financial institutions, and industry bodies. These partnerships must evolve from vendor management to co investment, shared data, aligned incentives, joint innovation, and common safety and sustainability standards.

Ultimately, India's opportunity is not constrained by ambition, is likely to be defined by execution. The strategic playbook is clear, build resilience by design, scale sustainability into commercial decision making, shift digital from pilots to enterprise operating infrastructure, deepen ecosystem partnerships, and engage proactively with policy. The deciding factor might be whether industry and ecosystem stakeholders can convert these advantages into integrated, safe, intelligent, sustainable, and globally trusted supply chain capabilities.

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The Indian Chemical Council (ICC) represents the USD235 billion Indian chemical and petrochemical industry. ICC is the apex national body in India that promotes and supports all branches of the chemical industry. Since its establishment in 1938, ICC is in the services of the Chemical & Petrochemical Industry in India. With membership spanning across producers, users, and transporters of chemicals-including key sectors like organic and inorganic chemicals, petrochemicals, agrochemicals, dyes, paints, and specialty chemicals, ICC serves as a vital bridge between industry, government, and civil society.

Through its extensive programming, ICC promotes responsible industry practices via:

Thought leadership: Policy advocacy, trade facilitation, and global chemical diplomacy

Capability building: Seminars, certifications, and ICC Annual Awards recognizing innovation and safety excellence

Standards and certification: As a government-authorized body, ICC issues Certificates of Origin and guides compliance with national and international norms

ICC is also the official steward of Responsible Care® in India, a global voluntary initiative for safety, health, and environmental excellence. With over 100 participating companies, ICC drives the adoption of best-in-class chemical management systems and promotes sustainability across the value chain.

Further strengthening its leadership in logistics safety, ICC runs the Nicer Globe initiative India's first GPS-enabled, emergency linked transport safety ecosystem for hazardous chemicals serving over 10,000 monthly shipments and collaborating with emergency services nationwide.

With offices in Mumbai, Delhi, Kolkata, Chennai and chapter in Vadodara, ICC continues to enable India's chemical industry to thrive responsibly, both locally and globally.

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