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AI in End-to-End Supply Chain Management:

From planning to autonomous execution

May 2026
Classification: Strictly Confidential

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A practitioner perspective grounded in real-world implementations across ports, warehousing and procurement, with practical relevance for organisations operating in Saudi Arabia.

Global supply chains are operating in an environment defined by volatility, fragmentation and rising service expectations. Demand patterns shift faster than planning cycles can absorb; product portfolios have grown more complex; supplier risk is now a board-level concern; and customers expect speed, transparency and reliability simultaneously. The traditional supply chain model, built on monthly planning cycles, siloed functions and deterministic assumptions, is no longer fit for this reality.

Artificial Intelligence (AI) is changing what is possible. It enables predictive, prescriptive and increasingly autonomous decision-making across the supply chain (Culot, Podrecca and Nassimbeni, 2024). More importantly, AI is shifting the operating model itself: from sequential planning to continuous re-planning, from reactive exception handling to anticipatory action, and from functional optimisation to genuine end-to-end orchestration; from demand sensing through sourcing, manufacturing, logistics, customer fulfilment and returns (Helo and Hao, 2022; Patil, 2024).

This article sets out where AI is creating measurable value across the supply chain today, drawing on direct implementation experience from port, warehousing and procurement environments. It is written for executives in Saudi Arabia who recognise the opportunity but are still navigating the practical question of where to begin and how to scale.

The challenges supply chain leaders are managing today

Before discussing AI capabilities, it is worth being precise about the problems organisations are actually trying to solve. In our work with clients in Saudi Arabia and the wider GCC, six challenges come up consistently:

Forecast volatility.	Demand signals are noisier and shorter-cycle than ever. Promotions, weather, social trends, geopolitical events and channel shifts all interact in ways that classical statistical forecasting cannot capture. The result is over-stock in some SKUs, stock-outs in others, and a steady erosion of margin.
Inventory imbalance and working capital lock-up.	Most organisations carry too much of the wrong inventory in the wrong locations. Static reorder points and one-size-fits-all safety stock policies are still common, even where SKU complexity has multiplied.
Supplier and lead-time risk.	Post-pandemic and post-Red Sea disruption, lead times are longer and less predictable. Visibility beyond tier-one suppliers remains poor, and procurement teams often discover risk only after it has already affected service.
Cost-to-serve pressure.	Energy, freight, labour and warehousing costs have all moved upward. At the same time, customers expect faster and more flexible delivery. The squeeze on margin is real and is forcing a hard look at how cost-to-serve is calculated and managed.
Data fragmentation.	ERP, WMS, TMS, supplier portals, IoT feeds and external data sit in disconnected systems. Decisions are being made on partial information, often manually reconciled in spreadsheets.
Talent and capability gaps.	Even where data and tools exist, the analytical and operational talent to translate them into decisions is in short supply, particularly across the GCC.

AI does not eliminate any of these challenges on its own. What it does do, when implemented thoughtfully, is convert them from structural constraints into manageable operational variables.

The industries feeling this most

Some sectors are exposed to these pressures more acutely than others, either because of the structure of their supply chains or because of the speed at which their markets are evolving. The following are the industries where, in our experience, AI is moving fastest from pilot to production:

Retail and e-commerce.	Short product lifecycles, high SKU counts, promotional intensity and customer expectations of next-day or same-day delivery make this the natural early adopter. Demand sensing, dynamic pricing and last-mile route optimisation are already mainstream in leading players.
Consumer products and FMCG.	Multi-echelon networks, promotional planning, perishables and channel proliferation create a high-volume decision environment that AI is well-suited to. Forecast accuracy gains here translate directly into working capital and waste reduction.
Pharmaceuticals and healthcare.	Cold-chain integrity, traceability, regulatory compliance, and demand variability make AI-enabled visibility and forecasting increasingly important. AI supports condition monitoring, inventory optimisation, serialization, packaging planning, and product availability while helping reduce shortages and pharmaceutical waste.
Industrial manufacturing and automotive.	Complex bills of material, supplier-driven lead times, capacity-constrained production and asset reliability all benefit from AI-driven scheduling, predictive maintenance and supplier risk intelligence.
Logistics, ports and 3PL.	High-volume logistics environments where inbound planning, workforce optimisation, vessel berthing, yard allocation, and space utilisation drive operational performance. AI is reshaping labour planning, dock scheduling, container balancing, fleet routing, and productivity forecasting to improve throughput and reduce operational cost.
Energy, oil & gas, and petrochemicals.	Asset-intensive, make-to-stock supply chains where inventory positioning, network resilience, demand forecasting, and scenario planning are critical. AI supports inventory allocation, storage optimisation, network planning, and supply continuity across globally distributed production and distribution hubs.
Construction and giga-project delivery.	A category of particular relevance in Saudi Arabia. The scale of NEOM, the Red Sea projects, Qiddiya and the broader giga-project portfolio is generating supply chain complexity at a magnitude that traditional planning approaches simply cannot absorb.

Saudi Arabia: a strategic hub between Asia, the Middle East, Africa and Europe

Saudi Arabia's geographic position, at the intersection of Europe, Asia and Africa, has always been a strategic asset. What has changed is the deliberate national programme to convert that geography into a logistics and supply chain advantage. Three pillars matter for this article:

National Transport and Logistics Strategy (NTLS)

Launched in 2021, the NTLS sets out the Kingdom's ambition to become a global logistics hub connecting three continents. The strategy targets a logistics sector contribution of 10% of GDP by 2030, a top-ten position on the World Bank's Logistics Performance Index, and the development of an integrated multimodal network spanning ports, airports, rail and roads. Around USD 133 billion of investment has been committed across the wider National Industrial Development and Logistics Programme (Ministry of Transport and Logistic Services, 2021; Vision 2030, 2024).

Global Supply Chain Resilience Initiative (GSCRI)

Announced in 2022, GSCRI is the Kingdom's direct response to the global supply chain disruptions of recent years. It positions Saudi Arabia as a destination of choice for global industrial companies seeking resilience and a strategic hub between Asia, the Middle East, Africa and Europe. The initiative targets SAR 40 billion of strategic supply chain investment, supported by SAR 10 billion in financial and non-financial incentives, with priority sectors including pharmaceuticals, automotives, aerospace, food processing, building materials, mining and renewables (Ministry of Investment, 2022; GSCRI, 2024).

Multimodal infrastructure and special zones

The Saudi Landbridge will connect the Red Sea (Jeddah) to the Arabian Gulf (Dammam) by rail, materially reducing transit times for cargo moving between Asia and Europe. Container capacity at Mawani-managed ports is being expanded toward 40 million TEU, and the Kingdom is building out roughly 40 logistics centres totalling more than 100 million square metres. Special Integrated Logistics Zones, including the one at Riyadh's King Salman International Airport, are designed to attract the regional headquarters and value-added logistics operations of multinational supply chains (Vision 2030, 2024; Mawani, 2024).

A national digital and AI agenda to match

The infrastructure agenda is paired with an equally ambitious data and AI agenda. The Saudi Data and Artificial Intelligence Authority (SDAIA) has established the National Strategy for Data and AI, the National Data Bank, and a National AI Index that benchmarks adoption across sectors (SDAIA, 2024). In May 2025, the launch of HUMAIN, a Public Investment Fund-backed AI vehicle, signalled the move from policy to capital deployment, including sovereign cloud and AI compute infrastructure designed to keep critical workloads inside the Kingdom (Public Investment Fund, 2025).

> The strategic logic is clear: a country that aspires to be the connecting node between Asia, the Middle East, Africa and Europe cannot rely on twentieth-century planning logic to run twenty-first century supply chains. AI is not optional for the GSCRI or NTLS ambitions to be realised; it is the operating layer that allows them to work at scale.

AI is a capability layer, not a single technology

It is more useful to think of AI as a capability layer that runs across the supply chain than as a discrete tool. That layer integrates data from ERP, WMS, TMS, CRM, supplier platforms, IoT devices and external sources, and converts it into decisions, recommendations and, in more mature deployments, autonomous action.

The value of AI is rarely captured by deploying a single use case. A more accurate forecast, on its own, delivers limited value if procurement, production, inventory placement, transport planning and customer order promising are not aligned to act on it. End-to-end AI implementation is about ensuring that one good decision informs the next, replacing functional silos with connected intelligence.

In practice, this means starting with a clear view of where the highest-value decisions sit, building the data foundation to support them, and then layering AI in a sequence that compounds rather than fragments. The next sections describe how this plays out across the supply chain, drawing where possible on direct implementation experience.

AI in planning

Demand sensing and forecasting

AI enhances forecasting by combining historical demand with a much wider set of internal and external signals: promotions, weather, macroeconomic indicators, seasonality, online search behaviour, customer sentiment, competitor actions and channel-level dynamics. Machine learning models capture non-linear relationships and adapt to new patterns far faster than traditional methods (Soori, Arezoo and Dastres, 2023; IRE Journals, 2024).

In implementation, organisations typically begin with the product families or business units where forecast error is most damaging, often high-volume SKUs with short lifecycles or highly seasonal demand. Models are trained on historical data enriched with the relevant external drivers, and forecasts are refreshed daily, or in some cases in real time. Mature deployments give planners not just a forecast number but a confidence interval, a bias indicator, a root-cause explanation and a recommended action.

In one warehousing implementation we worked on, an inbound forecasting model that combined historical receipt patterns with supplier ASN data, port congestion signals and seasonal indicators reduced inbound planning error materially and allowed labour and dock scheduling to be set days, rather than hours, in advance.

Demand shaping and dynamic pricing

AI-driven pricing engines continuously balance price elasticity, competitor positioning, inventory levels, supply constraints, service commitments and margin (Hu et al., 2024; Oteri et al., 2023). This is particularly relevant in retail, e-commerce, consumer products and any environment where availability fluctuates or perishability matters.

The point that often gets missed is that pricing AI must be integrated with the supply side. If inventory is tight, the model should suggest selective price increases or reduced promotional intensity to protect strategic customers. If inventory is long, it should propose targeted markdowns to accelerate sell-through and release working capital. In a procurement context, dynamic pricing logic can also work in reverse, supporting category managers in identifying the right time and the right supplier mix to commit spend.

Supply and inventory planning

AI moves inventory planning beyond deterministic reorder points and static safety stock. Probabilistic planning explicitly accounts for the uncertainty inherent in demand, lead times, supplier reliability, capacity and transport performance (Ahn et al., 2024). This is especially powerful in multi-echelon networks, where one node's decision affects the entire chain (IRE Journals, 2024).

A practical entry point is segmented inventory. AI models classify SKUs by demand variability, criticality, margin, supply risk and lifecycle stage, and recommend differentiated inventory policies rather than a single rule. In one warehouse environment, an AI-driven monthly ABC inventory re-allocation, combined with a dynamic slotting model, allowed us to reposition fast-movers closer to dispatch lanes, materially improve picking productivity, and free up storage capacity that had previously been locked in slow-moving stock.

S&OP and Integrated Business Planning

AI changes the character of S&OP and IBP. Instead of teams spending most of their time reconciling numbers, AI surfaces exceptions, runs scenarios, highlights risk and proposes corrective actions (Culot, Podrecca and Nassimbeni, 2024). Where a demand uplift is likely to cause a supply shortfall, where a capacity bottleneck will limit service, or how a supplier risk could affect a launch, these become proactive inputs to the leadership conversation rather than retrospective explanations.

The shift is from reporting to decision intelligence. Leadership teams can compare scenarios, weigh service-cost-risk trade-offs, and act on a much shorter cycle than traditional monthly S&OP allows.

AI in sourcing and procurement

Supplier risk intelligence

AI can monitor supplier performance and risk continuously, combining internal metrics (OTIF, quality incidents, lead-time variance, PO compliance) with external signals (geopolitical developments, financial distress indicators, port congestion, weather, sanctions). This allows procurement teams to act on emerging risk rather than respond to supplier failure after the event (Patil, 2024; Helo and Hao, 2022).

A typical implementation pattern is a supplier control tower that scores and ranks suppliers by criticality and exposure. AI-generated alerts feed escalation workflows, alternate supplier activation and inventory hedging decisions.

Spend analytics, contract intelligence and PO automation

Natural language processing can extract clauses, lead times, penalties, rebates and service levels from contracts at scale. Machine learning identifies spend patterns, consolidation opportunities and price trends across categories. This turns procurement analytics from a quarterly exercise into a continuous capability.

In one of the procurement automation projects we delivered, the rule set governing PO allocation, which supplier received which order under which conditions, was replaced by a model that considered current performance, capacity, price, lead time and risk in real time. The result was both faster cycle times and a measurable improvement in the share of spend going to best-fit suppliers.

Supplier collaboration and autonomous replenishment

For mature supply chains, AI supports collaborative planning with suppliers through shared demand signals, automated replenishment recommendations and dynamic re-prioritisation. This is particularly valuable for strategic suppliers and constrained categories, where standard planning cycles are too slow to be useful.

AI in manufacturing and operations

Production scheduling and capacity optimisation

Traditional production planning struggles to balance competing priorities against equipment status, workforce availability, material readiness and maintenance windows. AI-powered scheduling solves more variables simultaneously and re-optimises continuously as conditions change (Soori, Arezoo and Dastres, 2023). Factories can respond faster to urgent orders, disruptions and material variability.

Implementation typically connects AI models to the ERP and existing constraint-based planning tools. The model does not just produce a schedule; it monitors execution, identifies bottlenecks as they emerge and proposes recovery actions.

Predictive maintenance

Combining IoT sensor data with machine learning, predictive maintenance reduces unplanned downtime, extends asset life and stabilises output (Helo and Hao, 2022). The supply chain implication is direct: less schedule volatility, more reliable capacity, and a stronger basis for customer commitments.

Quality prediction and yield improvement

AI can identify process deviations, isolate the drivers of scrap or rework, and predict quality issues before final inspection. In sectors where quality failures are expensive, the case for these models is straightforward: lower waste, higher yield and reduced cost-to-serve.

AI in fulfilment and customer service

Intelligent order promising

AI-enabled Available-to-Promise (ATP) and Capable-to-Promise (CTP) deliver more reliable customer commitments by accounting for inventory, production, supplier availability, transit times and customer prioritisation rules. When disruption occurs, the model recalculates options, perhaps splitting an order, switching nodes, or adjusting the delivery window, while protecting margin and service.

Realising this requires strong integration across order management, ERP, WMS, TMS and production systems, and clear business rules on how strategic customers and channels are prioritised. AI optimises within those rules; it does not set them.

Proactive customer service

Rather than waiting for customers to ask where their order is, AI can predict likely delays and trigger notifications with revised ETAs and recovery options. Combined with conversational interfaces, this both reduces service workload and improves customer confidence.

Cost-to-serve and service differentiation

AI enables much sharper measurement of cost-to-serve at the customer and channel level. With that visibility, organisations can differentiate service models intelligently, aligning service levels with profitability, strategic importance and operational capacity, rather than offering the same service to everyone.

AI in logistics and distribution

Predictive logistics and transport planning

AI predicts disruption by combining carrier data, GPS, weather, port congestion, customs delays and historical route performance. It can recommend rerouting, mode switching, consolidation or priority escalation before service is affected (Chen et al., 2024). This shifts logistics management from reactive firefighting to predictive control.

Warehouse intelligence

Warehouse AI supports labour planning, slotting, picking-path optimisation, dock scheduling, replenishment timing, workload balancing and automation orchestration. Where robotics or autonomous storage are in place, AI dynamically allocates tasks based on urgency, congestion, order flow and resource availability.

A practical sequencing point: start with labour planning and slotting. Both deliver measurable benefits quickly, build organisational confidence in AI-driven operations, and create the data foundation for more advanced use cases such as computer vision for inventory checks, AI-guided robotics and exception handling.

Several leading WMS platforms are now embedding AI directly into their feature set, from OCR and automated ASN generation to AI-assisted exception handling. Working with these platforms in implementation has reinforced an important point: AI is most effective when it sits inside the operational system the warehouse team already uses, rather than as a separate analytical tool that someone else has to interpret.

Route and last-mile optimisation

AI-powered routing combines real-time traffic, weather, vehicle availability, driver constraints, order priority and delivery windows to optimise route efficiency. Models learn continuously from actual delivery outcomes, improving over time (Patil, 2024; Chen et al., 2024). This is decisive in dense urban networks and last-mile environments where variability is high and margins are thin.

Network flow orchestration

Beyond route-level optimisation, AI orchestrates flows across the distribution network: deciding where orders are fulfilled from, when, how inventory is repositioned, and how capacity is allocated across channels. This is where logistics AI starts to look less like an optimisation tool and more like a control layer for the network as a whole.

Generative AI in supply chain

The next wave of capability extends beyond predictive and optimisation models into generative AI (Ahn et al., 2024; Culot, Podrecca and Nassimbeni, 2024). Generative AI is most useful where supply chain teams are working with unstructured information: emails, contracts, supplier correspondence, disruption alerts, SOPs, maintenance logs, customer complaints and meeting notes. It can summarise issues, recommend actions, support planners with conversational analysis and accelerate root-cause investigation.

In practice, the most useful applications today include:

- Planner copilots that explain forecast changes and recommend planning actions.
- Procurement assistants that summarise supplier contracts, flag clauses and surface negotiation positions.
- Logistics copilots that interpret delay causes and propose recovery options.
- Warehouse assistants that guide supervisors through exceptions and shift-level decisions.
- Executive copilots that translate S&OP data into scenario narratives and decision options.

Generative AI does not replace transactional systems or optimisation engines. Its value is realised when it sits on top of them, combined with structured supply chain data, business rules and operational context.

How these AI capabilities accelerate Saudi Arabia's hub ambition

Bringing this back to the Kingdom's strategic positioning, the link between AI capability and the GSCRI and NTLS objectives is direct. The ambition to be the connecting node between Asia, the Middle East, Africa and Europe depends on the ability to move goods through Saudi Arabia faster, more reliably and at lower cost than the alternatives. That is exactly where AI delivers.

Faster port and customs clearance.	AI-driven document processing, risk-based inspection and predictive yard and berth planning support the NTLS target of 24-hour container clearance and the broader move toward digital, paperless trade.
Higher port and warehouse throughput.	Container balancing, dynamic slotting, intelligent labour scheduling and AI-orchestrated automation directly raise the operational ceiling of port and logistics-zone capacity, without proportional increases in cost.
Reduced logistics cost share of GDP.	Route optimisation, network flow orchestration and intelligent transport planning lower the cost of moving goods both within the Kingdom and through it. This is one of the most direct levers for the NTLS target of raising the sector's contribution to 10% of GDP.
Stronger supplier and inventory resilience.	AI-driven supplier risk intelligence, multi-echelon inventory optimisation and dynamic sourcing are exactly the capabilities GSCRI is trying to attract, both to make the Kingdom a resilient supply chain location and to make Saudi-based operations a resilience option for global manufacturers.
Localisation and giga-project delivery.	Vision 2030 localisation targets, in pharmaceuticals, food, defence and industry, and the supply chain demands of NEOM, the Red Sea Project, Qiddiya and the wider giga-project portfolio create planning complexity that traditional methods cannot absorb. AI-enabled planning, scheduling and procurement are the practical mechanism for delivering at this scale.
Sovereign and sustainable AI deployment.	With HUMAIN, SDAIA's data and AI frameworks, and growing local cloud capacity, organisations operating in the Kingdom can deploy AI in a way that meets data residency, regulatory and ESG expectations, an increasingly important condition for both global and local clients.

In short, the AI capabilities described in this article are not parallel to the GSCRI and NTLS agendas; they are the mechanism by which those agendas are operationalised. Without them, the geography is a starting point. With them, the Kingdom becomes a system.

A realistic view from the ground

Two observations from working on AI implementations across the GCC are worth underlining for executives considering their next move.

- First, very few organisations in Saudi Arabia have yet built the in-house capability to design, deploy and scale AI in the supply chain. Most are still at the stage of recognising the opportunity and exploring isolated use cases, often without a clear architectural view of how those use cases connect. The result is pilots that work but never scale, and AI investments that do not move the operating model.

- Second, the organisations that succeed share a recognisable pattern. They sequence their AI roadmap from high-value, well-bounded decisions outwards. They invest in the data foundation before chasing model sophistication. They embed AI inside the operational systems their teams already use, rather than alongside them. They treat governance, change management and capability-building as part of the implementation, not as something to be added later. And they measure AI investments on operational and financial outcomes, throughput, working capital, cost-to-serve, service level, not on technology metrics.

This is not a technology challenge. It is an execution challenge, and it is the one that will separate the organisations that benefit from Saudi Arabia's logistics transformation from those that simply observe it.

Closing thought

AI is not a future capability for the supply chain. It is a present one, and it is being deployed today across ports, warehouses, factories, distribution networks and procurement organisations in ways that are measurably changing performance. For Saudi Arabia, the convergence of Vision 2030 infrastructure, the GSCRI, NTLS, sovereign AI capacity through HUMAIN and SDAIA, and a young, digitally native workforce, creates a window in which AI adoption can compound national advantage rather than merely keep pace with global peers.

At Grant Thornton Saudi Arabia, we work with clients across these sectors to translate this opportunity into practical, implementable change, from supply chain strategy and operating model design through to data architecture, AI use-case prioritisation and operational deployment. The organisations that move now, and move with the right sequencing, will define what Saudi Arabia's end-to-end supply chains look like for the next decade.

Visual: AI across the end-to-end supply chain

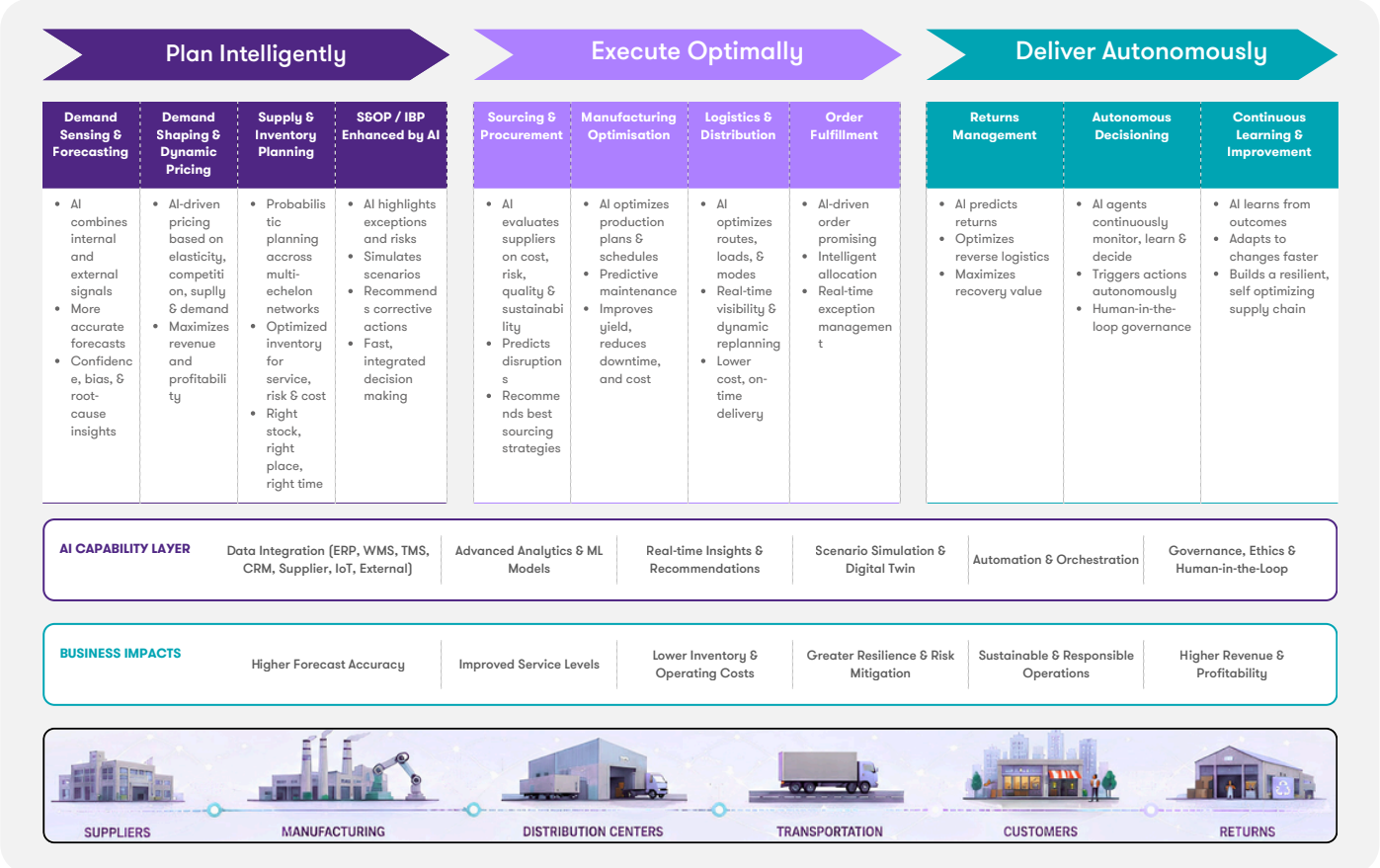

Figure 1. AI across the end-to-end supply chain: from intelligent planning to autonomous execution.

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About this article

This article reflects practitioner experience implementing AI across warehousing, inbound forecasting, space utilisation, ABC inventory re-allocation, resource and labour planning, PO automation and procurement pricing, including direct work with Warehouse Management System providers on embedding AI features such as OCR and automated ASN creation. Literature review supports and contextualises this practical experience.

Author

Sofia Raptopoulou

Director, Business Consulting
E: sofia.raptopoulou@sa.gt.com
M: +966 (11) 463 0680

Aldar Audit Bureau
Abdullah Al-Basri & Co.
Member firm of Grant Thornton International Ltd.
Grant Thornton

grantthornton.sa

Riyadh
U Walk, C4 2nd Floor
Prince Turki Ibn Abdulaziz Al Awal Road
T +966 (11) 463 0680

Jeddah
Crystal Tower, 2nd Floor
King Fahad Road
T +966 (12) 691 6883

Dammam
7th Floor, Ababtain Tower
Custodian of the Two Holy Mosques Road, Al-Khobar
T +966 13 896 0592