The future of S&OP: How AI is revolutionising supply chain planning for paper & packaging

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INTRODUCTION:

The paper and packaging industry is navigating an era of profound transformation. Heightened environmental concerns, rapidly shifting consumer behaviour, supply chain vulnerabilities, and an increasingly complex global trading landscape all present formidable challenges. These dynamics make effective planning more important—and more difficult—than ever before. Sales and Operations Planning (S&OP) has long been a cornerstone of supply chain success. In today's environment, however, traditional approaches to S&OP no longer provide the agility and precision businesses need. That's where Artificial Intelligence (AI) comes in.

Challenges Unique to Paper & Packaging Forecasting Industry-specific forecasting challenges include:

- Demand swings due to seasonality and promotional activities: Seasonality in paper products and campaign-based demand in packaging can cause sharp fluctuations, making stable forecasting difficult.
- Long lead times in paper production: These often necessitate buffer stocks, the visibility of which depends on business models in use. Typically, different forms of VMI (Vendor Managed Inventory) are far more transparent to call-off agreements (commonly used in paper industry). Greater transparency at the supplier leads to lower working capital requirements.
- SKU proliferation and customisation: Packaging is often tailored by customer or region and additionally driven by end-product or brand marketing campaigns, which adds complexity to forecasting.
- Sustainability pressures: Regulatory shifts like the EU Deforestation Regulation (EUDR) and the potentially expanding scope of CBAM following EU Green Deal framework are pushing companies to plan more transparently and responsibly.

AI Beyond GenAI: The Strength of Machine Learning & Simulation in Supply Chain Planning

While generative AI is gaining visibility for its conversational and content-creating capabilities, many of the most impactful applications of AI in supply chain planning come from more traditional AI methods—specifically, non-generative machine learning (ML) and simulation techniques, as noted in a recent Gartner study.

These technologies excel at digesting structured data, identifying patterns, optimising variables, and generating probabilistic insights. In fact, for the six core areas of supply chain planning, ML and simulation provide practical, scalable solutions that are already delivering tangible value.

Supply Chain Planning Use Case Suitability

AI techniques in supply chain planning heat map

Low (L) Medium (M) High (H)

Supply chain planning use cases	Common AI techniques				
	Generative	Nongenerative machine learning	Optimization	Simulation	Rules/ heuristics
Data governance	M	H	L	M	M
Demand Preprocessing	M	H	L	H	L
Demand forecasting	L	H	L	H	M
Supply planning	L	L	H	H	M
Risk management	M	H	L	H	L
User experience	H	H	M	L	M

Source: Gartner

Gartner

1. Demand Planning & Demand Reprocessing

Non-generative ML use case:

XGBoost-based demand forecasting. By applying tree-based ensemble models to historical order data, companies can identify complex interactions between variables (e.g., promotions, seasonality, customer segments) and improve forecast accuracy by 15–30% versus traditional time series models.

Real-time demand adjustment using supervised learning (e.g., XGBoost or Random Forest). ML models can continuously learn from incoming short-term signals like:

- POS Data
- eCommerce transactions
- Weather changes
- Promotion lift variances
- Macroeconomic shifts (e.g., CPI spikes)

These models reprocess the original baseline forecast and update short-term SKU-level demand across the horizon. This is particularly useful when:

- A sales campaign underperforms or overperforms
- A competitor launches a surprise product
- An unexpected event (e.g. sports event win, regulatory news) boosts specific category demand

As an example a corrugated packaging producer sees a spike in demand for specific ecommerce boxes due to Black Friday week trending stronger than predicted. The ML model reprocesses recent demand signals, identifies the new baseline, and adjusts replenishment recommendations for key box SKUs in real time.

Simulation use case:

Scenario simulation for product launches. Companies simulate multiple demand curves for new SKUs using historical analogs, allowing planners to stress-test capacity and inventory positions before launch.

Simulation models can test how different demand reallocation scenarios affect the supply chain in real time. This includes:

- Allocating constrained raw materials or machine time
- Reprioritising orders across regions or customers
- Assessing lead-time trade-offs for urgent replenishments

A pulp and paper company experiences an unexpected demand shift from Southern to Northern Europe. Simulations assess:

- How to redirect stock-in-transit o Which production lines can accommodate the new mix o The impact on service levels and logistics costs

The simulation provides planners with options ranked by feasibility and cost impact, allowing them to reprocess demand with operational realism.

2. Inventory Planning

Non-generative ML use case:

- Predictive safety stock modelling. ML models ingest lead time variability, supplier reliability, and historical stockouts to dynamically recommend safety stock levels by SKU-location, reducing inventory by up to 20% while maintaining service levels.

Simulation use case:

- Multi-echelon inventory simulations. Simulates how inventory flows and buffers behave across the network under different demand and disruption scenarios, supporting optimal positioning of stock.

3. Production Planning

Non-generative ML use case:

- Predictive maintenance for production scheduling. Using ML to predict machine downtimes enables better sequencing and resource planning, reducing unplanned delays and enabling more reliable execution of production plans.

Simulation use case:

- Finite capacity production simulations. These simulate the impact of production constraints (machine, labor, changeovers) under different plans, helping planners choose the most feasible and cost-efficient schedule.

4. Network Planning

Non-generative ML use case:

- ML-driven cost-to-serve models. These models analyse order patterns, shipping costs, and customer behaviours to recommend optimal regional distribution points and transportation modes.

Simulation use case:

- Network design simulations. Planners model the effect of adding/removing warehouses, changing production locations, or rerouting transport to evaluate trade-offs in cost, lead time, and service.

5. S&OP Scenario Planning

Non-generative ML use case:

- Revenue/margin optimisation. ML models evaluate product mix scenarios against historical sales elasticity, pricing sensitivity, and cost structures to recommend the optimal scenario in S&OP meetings.

Simulation use case:

- S&OP scenario war-gaming. Teams simulate different demand and supply-side scenarios (e.g., raw material shortage, spike in demand) across a 12–18 month horizon to stress-test financial and operational KPIs.

Another relevant use case involves rebalancing supply to accommodate shortterm demand shifts. Simulation scenarios test how shifting product availability or logistics flows can satisfy updated regional demands within existing constraints. A real-life example of such is where paper supplier must redirect volume from Spain to Germany. Simulation assesses the impact on service levels, lead times, and costs, guiding the planner's next-best actions.

6. Sales and Operations Execution (S&OE)

Non-generative ML use case:

- Dynamic replanning algorithms. Real-time demand signals (orders, POS data, weather, etc.) are ingested by ML models that adjust short-term supply signals like delivery plans or material allocations.

Simulation use case:

Short-term execution playbooks. Simulation tools support rapid evaluation of next-best actions in case of unexpected changes—e.g., customer delays or line shutdowns—helping teams decide within hours, not days.

Why Non-Generative AI and Simulation Work Best in Practice

- Machine learning excels in repeatable, data-rich environments where relationships are too complex for human detection but structured enough for algorithms to optimise.
- Simulation excels in uncertain, constraint-heavy environments where scenario testing helps de-risk decisions and align stakeholders around trade-offs.

Rather than replacing planners, these tools augment their capability—freeing time from number crunching and enabling more strategic, data-informed discussions across the business.

The Power of Edge AI, Predictive Alerts, and Collaboration

There are several steps paper industry operators need to take to address the still commonly fragmented supply chains and disconnected data flows. Improving these processes toward a more agile and resilient setup is critical to responding effectively to disruptions occurring anywhere along the supply chain. While many companies have already made significant progress, there is still important work to be done.

It is still common in the paper and packaging industry to operate at a relatively slow pace when it comes to supply chain decision-making—particularly in S&OP. Many companies rely on quarterly or monthly S&OP cycles, based on the belief that faster planning is not feasible. However, this assumption is outdated. Increasingly, it's important to integrate S&OP with short-term Sales & Operations Execution (S&OE) and to build tactical planning capabilities that support weekly and ad-hoc scenario creation—especially with the help of modern planning tools.

In many cases, real-time, end-to-end data sharing remains absent across the supply chain—even when both ends of the chain are owned by the same company. This lack of integration makes it even more essential to establish real-time platforms that enable key partners to collaborate more effectively.

It is strongly recommended that organisations across the ecosystem begin leveraging AI to better coordinate key processes, such as demand planning and timely capacity adjustments.

To fully capitalise on AI's potential, several innovations are being rapidly adopted:

- **Edge AI:** Localised AI models installed directly at mill or plant level enable nearinstant insights on shop floor realities. As an example these models can adjust production forecasts based on machine availability, material delays, or shift patterns, driving smarter micro-decisions.
- **AI-Augmented Collaboration:** AI-generated scenario visualisations and forecasts can be shared in S&OP meetings to enrich discussions. This promotes cross-functional alignment, helping commercial, operations, and finance teams co-create action plans.
- **Predictive Alerts:** AI tools continuously monitor real-time data and generate alerts when conditions deviate from plan. For instance, sudden drops in raw material availability or order volumes trigger automatic suggestions for replanning.

Connecting AI Forecasts with Execution: The ERP & APS Integration Imperative

AI-powered forecasts only realise their full potential when seamlessly connected to execution systems like ERP and APS. For example:

- ERP Integration (SAP, IFS, Oracle, Microsoft, etc.): I-Plan integrates with leading ERP systems to push accurate demand forecasts and receive execution feedback. This enables closed-loop planning where short -term demand sensing helps to adapt forecasts based on actual order intake, production realities, and shipment schedules.
- End-to-End Visibility: Integration ensures that insights are shared across the business, aligning planning with procurement, logistics, and finance. It removes data silos and makes real-time collaboration possible between upstream suppliers and downstream customers.
- Execution Alignment: Accurate forecasting feeds directly into production orders, transport planning, and inventory restocking—ensuring that planning isn't just theoretical but operationally actionable.

Transitioning from Manual to AI-Driven Forecasting

Many companies still rely on Excel or ERP-generated static forecasts. Moving to AIdriven planning requires cultural and capability shifts:

- Mindset Change: Planners shift from "owning the number" to "guiding the system". Instead of manually manipulating forecasts, they now oversee automated predictions and validate them with business context.
- Onboarding Support: At I-Plan, we provide structured onboarding programs and hands-on training to help teams adapt. Visual analytics and intuitive dashboards make adoption smooth.
- Confidence in the System: Early wins build trust. For example, one planner at an I-Plan customer noted, "Before I-Plan, we were constantly firefighting. Now we can finally think ahead to grow the forecast value-add."

The Human Element: Why Planners Still Matter

AI doesn't replace planners— the use of AI rather empowers them.

Many limitations still exist:

- AI can't interpret politics, contracts, or intuition
- Poor data leads to poor outputs
- Explainability remains a challenge in some models

Human oversight remains essential. Planners are now strategic enablers, guiding the AI, injecting context, and ensuring cross-functional buy-in.

A client planner put it best: "With I-Plan, we're not just planning better—we're finally having the right conversations at the right time."

Forecasting Tailored to Every SKU: The Power of Expert Selection

I-Plan's "Expert Selection" tool addresses the reality that no one-size-fits-all approach works for all SKUs. It dynamically selects from 14 statistical methods, including models like:

- Exponential Smoothing
- Box-Jenkins (ARIMA)
- Moving Average
- Croston's Method
- Delphi Method

Each SKU is analysed individually, ensuring the most suitable model is used and updated continuously. For companies managing thousands of SKUs, this level of automation delivers speed, accuracy, and confidence.

Improving Forecast Accuracy with MAE, MAPE and Forecast Value Add (FVA)

Forecast accuracy is a critical performance metric in supply chains with high variability and long lead times—like in the paper and packaging industry. Among the many KPIs, three stand out for their practical value: Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Forecast Value Add (FVA).

Forecast MAE measures the average absolute difference between forecasted and actual values in real units (e.g., tons). It's easy to interpret and unbiased toward over- or under-forecasting but is not scale-independent—making comparisons across products challenging.

MAPE, by contrast, expresses forecast error as a percentage, making it ideal for comparing performance across SKUs or business units. In I-Plan's Expert Selection tool, multiple statistical methods are applied at the SKU level, and the model with the lowest MAPE is selected—often resulting in forecast accuracy improvements exceeding 20% within weeks.

While MAE and MAPE assess statistical accuracy, FVA asks: Did human adjustments improve the forecast or make it worse? It compares different versions of the forecast:

- Naïve forecast (e.g., last period's actuals)
- System-generated forecast (statistical or ML-based)
- Planner-adjusted forecast
- Final consensus forecast (e.g., post-S&OP)

FVA helps identify where human input adds value—and where it introduces bias. For example, if a sales override increases MAPE from 20% to 32%, FVA highlights this as a negative contribution, showing the system forecast would have been better left untouched.

Best practices include:

- Tracking MAE/MAPE and FVA in parallel
- Making FVA results transparent to planners
- Limiting manual overrides to low-volume or highly variable items
- Requiring real market insight for any adjustments

Over time, this creates a feedback loop that boosts trust in system-generated forecasts and enhances collaboration across functions. At I-Plan, we see forecast accuracy not just as a technical metric—but as a strategic lever that enables smarter, faster decisionmaking.

Aligning forecasting with the planning hierarchy is essential across:

1. Strategic Planning (12–36 months) – Capacity and CAPEX
2. Tactical Planning (3–18 months) – Procurement and production
3. Operational Planning (0–12 weeks) – Execution and S&OE

I-Plan helps organisations ensure forecasts support each horizon consistently connecting insights to action across the business.

A global paper packaging business improved forecast accuracy by 20% and significantly reduced working capital

A global packaging paper operator applied I-Plan across its operations focusing first in improving monthly forecasting and second phase in improving supply planning and demand/supply balancing based on profitability (advanced S&OP), achieving:

- 20%+ improvement in SKU-level forecast accuracy
- Reduced safety stock and working capital
- Substantially improved service levels and delivery reliability

Similarly a northern European paper group producing graphic fine paper based products implemented I-Plan to combat variability in niche market demand. Results included:

- Significantly reduced forecast error
- Better alignment between sales and production/ operations
- Faster responsiveness to short term customer changes

Conclusion

The future of supply chain planning and S&OP in the paper and packaging industry is intelligent, integrated, and data-driven. As customer examples show, AI no longer just supports forecasting—it's reshaping how businesses plan and respond.

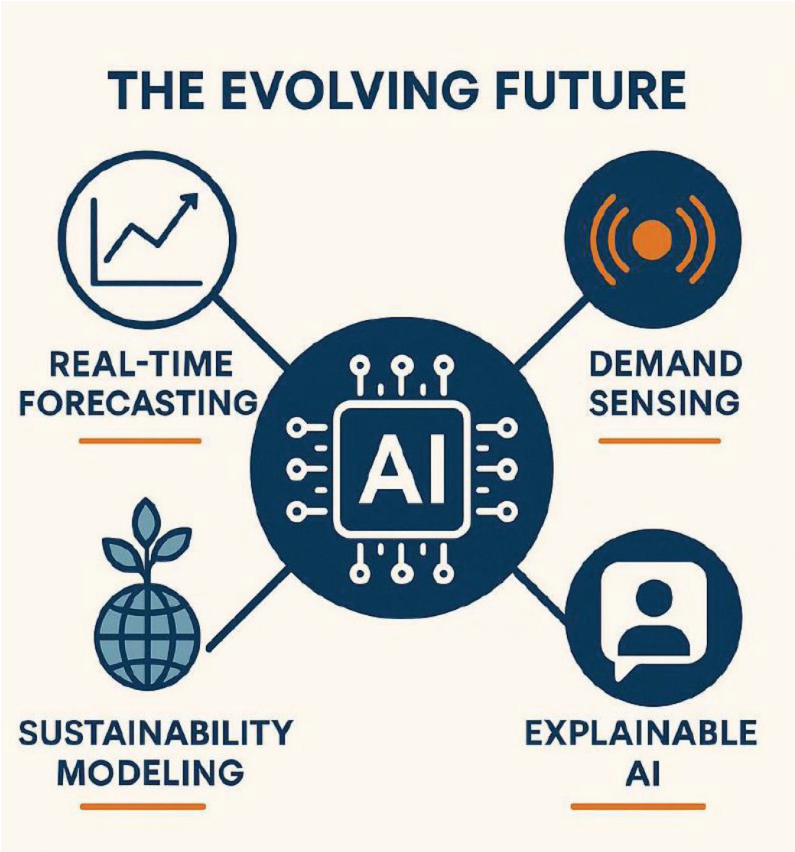
AI is becoming deeply embedded across the planning process: from sourcing and capacity decisions to risk evaluation and execution.

Recent trends driving this transformation include:

- Real-time forecasting via IoT and cloud data
- Demand sensing from unstructured signals (e.g. social, news)
- Sustainability-aware planning (e.g. emissions, waste)
- Explainable AI to increase transparency and trust

In many recent supplychain planning focused conferences, it has become clear that leading manufacturers are moving beyond static scenarios toward continuous, simulation-based decision-making. Instead of planning for fixed outcomes, today's simulation engines run persistently—digesting real-time data, modelling disruptions, and guiding adaptive responses. Paper and packaging companies need to follow the rhythm to keep their positions.

Rather than relying on predefined best-case or worst-case models, simulation engines are now expected to run continuously. These engines ingest real-time data, model disruptions across functions, and recommend adaptive actions. This marks a structural evolution in the way planning is conducted.



Generative AI (GenAI) offers further promise through agents that can autonomously generate forecasts, explore what-if scenarios, and propose plans using near real-time inputs. This unlocks proactive planning across all horizons—from strategic to operational. Yet, traditional AI techniques (like statistical models and optimisers) still outperform GenAI in accuracy-critical, constraint-heavy use cases.

Crucially, GenAI excels at collaborative intelligence—making insights more accessible across departments. This empowers commercial, financial, and operational teams to engage with data in ways previously limited to technical planners.

The companies thriving today understand that resilience is no longer just a process—it's an outcome of smart, AI-enabled planning systems designed to sense, anticipate, and act.

At I-Plan, we help organisations turn AI into a strategic S&OP advantage—combining machine-driven insight with human expertise.

Ready to explore your AI potential? Visit [www.iplanworld.com] or contact us to start your journey.