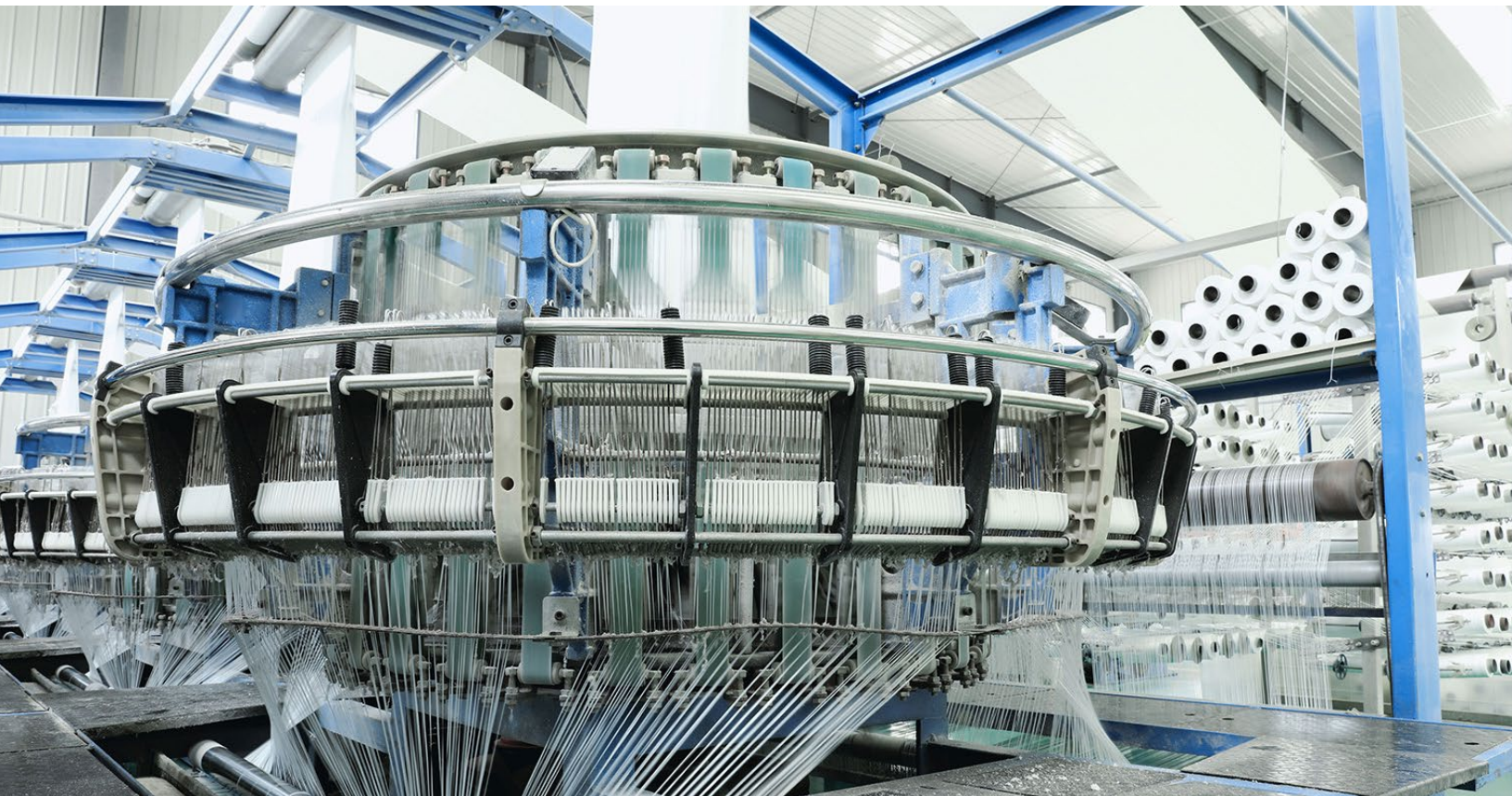


Operations Practice

Building the system-led factory in textile and apparel manufacturing

Leading textile and apparel manufacturers are redesigning their production systems around AI, automation, and tightly controlled process execution to unlock more than 30 percent in productivity gains.

This article is a collaborative effort by [Javier del Pozo](#), [Ken Somers](#), [Patricio Ibáñez](#), and [Pratik Goyal](#), with Minsu Kim and Sangyoung Cho, representing views from McKinsey's Manufacturing and Supply Chain Practice.



For decades, the textile and apparel manufacturing industries competed primarily on scale, labor, and individual craftsmanship. Competitive advantage was built on the strategic ability to mobilize large, skilled workforces and manage high operational complexity through accumulated experience, hands-on supervision, and incremental improvements. In an environment where labor cost arbitrage was a primary driver of performance, variability was expected and largely absorbed through human intervention and the intuitive decision-making of highly experienced managers.

This traditional model, however, has now reached its structural limits. Manufacturers are—rightly—investing in high standards of pay and working conditions for frontline staff. Rising costs across key sourcing markets, increasing product complexity, shorter lead times, and volatile demand are exposing deep-seated inefficiencies embedded in labor-intensive production systems. At the same time, global brands are raising expectations for speed, reliability, digital integration, and end-to-end transparency, fundamentally reshaping the manufacturing platform. The implication is clear: The next frontier of competitiveness is not cheaper labor, but productivity driven by integrated systems.

In response, leading manufacturers are shifting from improvisation-dependent execution to process-dependent systems. This transformation defines the system-led manufacturing model, where performance is no longer dictated by individual skill or isolated “hero” line leaders, but by standardized processes, embedded intelligence, and scalable capabilities deployed consistently across factories and geographies. This systemic shift is enabled by four strategic levers: digital and AI, automation, operational excellence, and energy optimization. Within the digital lever, the trajectory points clearly toward agentic AI—systems that not only recommend but autonomously execute optimal decisions. Deployed in combination, these levers consistently unlock productivity improvements exceeding 30 percent, alongside meaningful cost reduction and enhanced operational resilience. Ultimately, the apparel factory of the future will be defined by the robustness and performance of its systems.

Efficiency as a strategic imperative: The shift to integrated systems design

The performance equation in apparel manufacturing has fundamentally changed. Across the consumer sector, growth remains uncertain while margin pressure continues to intensify. As a result, productivity—not just volume—has become the primary driver of value creation. Leading companies are now simplifying their operating models, reallocating capital toward technology, and accelerating execution across their entire value chains.

Digital and AI are central to this shift, moving from experimental tools to the baseline for participation in global supply chains. Manufacturers are now expected to demonstrate high digital maturity and real-time visibility; in fact, leading brands have introduced formal digital maturity indices to select and prioritize suppliers. In parallel, structural pressures are accelerating. Labor costs are rising across many manufacturing markets, while orders are becoming more fragmented, with smaller batch sizes and shorter product life cycles. Historically, manufacturers addressed this complexity by growing their workforce and relying on the experience of supervisors to manage variability. Today, these approaches alone are often insufficient to address the economic and operational demands of increasingly complex production environments. True efficiency now requires a fundamental transition from labor optimization to integrated systems design. The objective is to redesign the system end to end, reallocating complexity from people to standardized processes. In traditional environments, high-performing supervisors are often those capable of resolving chaos through intuition and nonstandard workarounds. In a system-led factory, by contrast, success is driven by the disciplined execution of standardized processes and the use of

real-time data for decision-making. By transferring execution intelligence into process design—such as semiautomated stations where a single operator oversees multiple machines—manufacturers eliminate variability at its source. The standardization and simplification of tasks ensure that performance remains stable and replicable, regardless of individual skill gaps.

Digital and AI: The coordinating layer of the factory

Digital and AI are becoming the central orchestrating layer of modern apparel manufacturing. Their role is not simply to digitize existing processes, but to fundamentally reshape how decisions are made, executed, and continuously improved.

In leading factories, AI is being used to optimize production planning by simulating multiple scenarios based on order mix, line performance, operator skill matrices, and operational constraints. Rather than relying on planner intuition, these systems generate optimized allocation scenarios, enabling decisions to be made based on quantified trade-offs between efficiency, cost, and delivery risk. In practice, this approach typically delivers an approximately two-percentage-point improvement in sewing efficiency, while significantly reducing planning cycle time, reducing the downtime required for product changeovers, and improving delivery reliability.

At the shop floor level, real-time performance management systems provide a second layer of impact. These systems continuously track output, cycle times, and bottlenecks at the station level, enabling immediate identification of performance deviations. More advanced implementations go beyond visualization, linking detected issues to predefined corrective actions based on standardized best practices.

For instance, a manufacturer might move from static performance boards to an action-oriented digital layer that surfaces deviations in real time and prompts standardized corrective actions, helping line leaders hold hourly targets across shifts—typically delivering several percentage points in efficiency improvement, faster ramp-up on new styles, and less intra-day variability.

The next frontier is agentic AI: systems that move beyond diagnoses and recommendations to autonomously orchestrate decisions across functions. Rather than optimizing planning, line management, quality, and material flow in isolation, agentic systems operate on an integrated data foundation—generating optimal sourcing and production-allocation scenarios against margin targets and capacity constraints, tracing quality deviations back to upstream material lots, and triggering corrective or preventive actions with minimal human intervention. The true step change, however, comes from integration.

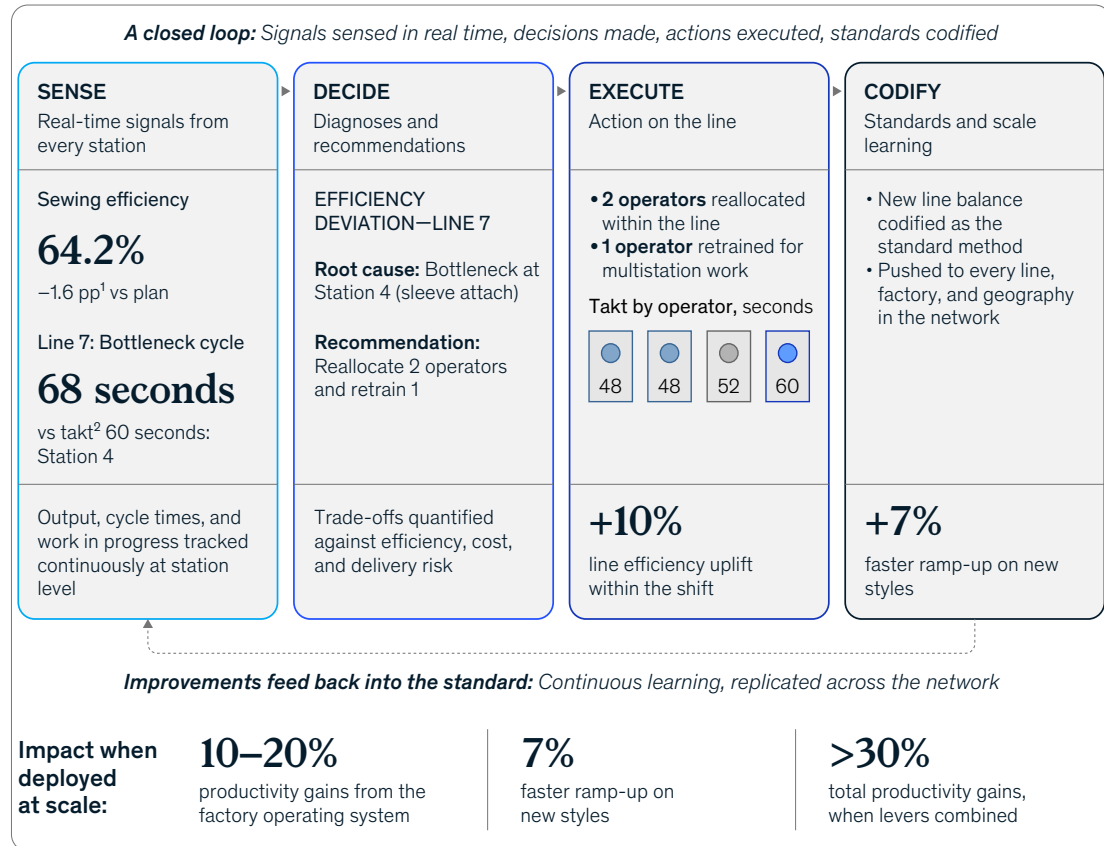
Leading manufacturers are moving beyond isolated use cases to build what can be described as an **integrated factory operating system**. In this model, multiple digital and AI capabilities are embedded across core processes such as planning, line management, quality control, and material flow (exhibit).

This creates a closed-loop performance system in which data is continuously captured, deviations are automatically identified, root causes are analyzed, and corrective actions are systematically implemented—increasingly orchestrated by agentic AI rather than manual escalation.

Exhibit

A single agentic system can sense shop floor deviations, decide on the optimal correction, execute it on the line, and codify the result as standard.

Closed-loop agentic AI on the shop floor, illustrative textile and apparel manufacturing dashboard



¹Percentage point.

²Takt time is the target pace of production required to meet customer demand.

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While increasingly autonomous systems can improve operational responsiveness, human oversight remains essential for governance, exception management, and continuous improvement. Improvements are codified into standard processes, enabling continuous learning and scalable performance. When deployed at scale, such systems can deliver overall productivity improvements of 10 to 20 percent.

A particularly high-impact opportunity lies in indirect functions, especially industrial engineering (IE) and work-study activities. Illustratively, a digital solution can automatically balance sewing lines and generate optimal layouts based on material flow, operator density, multimachine configurations, and workstation constraints, while proposing style-specific ramp-up curves—reducing reliance on manual engineering analysis and improving consistency across lines.

Emerging applications are also being tested to automatically generate standard minute values (SMVs) and construction sequences directly from computer-aided design (CAD). While still under development, these use cases have the potential to fundamentally transform engineering functions in apparel manufacturing by standardizing one of the most variable and experience-dependent activities.

In textile production, companies are applying AI tools to optimize cotton mix and machine parameters against customer specifications in spinning, anticipate loom breaks and shortages in weaving, and drive lab-to-bulk reproducibility, shade prediction, and dynamic batch sequencing in dyeing and processing. AI-powered visual inspection systems are providing real-time feedback and reducing defects in knitting.

Today's most advanced digital systems are linking fiber inputs, yarn lots, recipes, machine settings, utilities, quality outcomes, and delivery signals into a single operating spine. Mills that embed these technologies into planning, KPI tracking, and root-cause loops are seeing a 5 to 7 percent uplift in the quality of wet processing, as well as significant improvements in utility consumption and schedule adherence.

Automation: Enabling structural productivity

Automation in textile production is shifting from asset intensity to loss elimination. The next wave is not about adding more machines; it is about eliminating the causes of lost output, with closed-loop control of mix and spindle speed in spinning; real-time stop-cause capture and speed tuning in weaving; and automated dosing, recipe lockouts, endpoint control, and bottleneck synchronization in wet processing. In this model, automation becomes a capacity multiplier—boosting output by 8 to 10 percent along with significant reductions in reprocessing, energy, and lead times, without a step change in capital expenditure.

In apparel manufacturing, automation is evolving from isolated applications to become a central element of manufacturing system design. Advances in robotics, machine vision, and control systems are expanding the range of processes that can be automated, particularly in areas characterized by high repetition, standardized motion, and limited variability in material handling or positioning. Today, the highest-impact applications are emerging in finishing, sewing support, and intralogistics.

In finishing operations, robotic packing systems are delivering substantial impact by integrating multiple manual tasks—such as folding, bagging, labeling, and palletizing—into a single automated flow. These systems standardize execution, eliminate operator variability, and reduce dependency on manual handling. In practice, this results in a 70 to 80 percent increase in the productivity of direct labor, while improving cycle times by 50 to 60 percent and significantly enhancing consistency.

In sewing, automation is less about full replacement of operators and more about **restructuring work content**. Semiautomated solutions dramatically reduce cycle times by combining multiple operations into integrated stations, often supported by automated material positioning, guiding mechanisms, and robotic transfer between substeps. This also allows a single operator to oversee processes that previously required multiple workers, primarily focusing on loading and unloading tasks.

The key mechanism is the elimination of intermediate handling and the stabilization of process sequences. By reducing manual variability and synchronizing operations, these solutions enable near-continuous

flow within the workstation. In targeted use cases, automation has enabled some stations to operate with substantially reduced manual intervention and fewer operator touchpoints, while delivering productivity improvements of 20 to 40 percent at the line level. Automation is also transforming intralogistics, where material movement between processes has historically been labor-intensive and highly variable. Autonomous guided vehicles and smart material-handling systems are increasingly used to transport bundles, rolls, and finished goods across the factory. These systems operate based on real-time demand signals, ensuring timely material availability while reducing idle time. Their impact is significant. Indirect labor productivity increases by up to 80 percent, flow predictability improves, and bottlenecks caused by material shortages or delays are reduced.

Automation fundamentally enables the system-led manufacturing model by decreasing dependency on scarce specialized skills while enabling operators to work more consistently within production systems that are standardized across lines and factories. It also plays a critical role in reducing ramp-up time for new styles, as performance becomes less dependent on operator learning curves and more driven by system configuration.

Operational excellence: The foundation of performance

Despite advances in digital and automation, operational excellence remains the foundation upon which all other levers depend. Time and motion studies consistently reveal substantial deviations from engineering benchmarks. It is not uncommon to observe operations performing at half their theoretical capacity due to poor synchronization between stations, excessive work in progress (WIP), and unbalanced task allocation.

These inefficiencies are often amplified by the way performance is managed. Many manufacturers focus on optimizing individual lines or stations, aiming to maximize local operator utilization. This inherently limited approach treats production as a series of isolated steps. The more advanced approach is to shift from line-level optimization to flow-level optimization. The objective is to ensure continuous and synchronized material movement across the entire value stream by minimizing WIP buffers, reducing waiting times, and aligning cycle times. This shift requires a combination of engineering rigor and operational discipline, executed through a three-phased approach: line design, ramp-up, and line management.

Phase 1: Line design

Operational excellence begins even before the physical layout is drawn. A recurring issue in many factories is the disconnect between reported and actual performance. Historical efficiency metrics are often based on inflated or inconsistent SMVs, which mask underlying productivity gaps and create a false sense of control. Therefore, the absolute first step is establishing accurate, observation-based SMVs to replace manual adjustments and set realistic capacity targets.

Armed with this true baseline, leading manufacturers evaluate layout configurations using a rigorous line-design score with a strict minimum threshold. If a proposed layout fails to meet this threshold, it is completely redesigned. This discipline, combined with skill-based operator allocation that matches tasks to individual capability, forces a simplification of logistic flows. Material presentation and handling are redesigned to minimize non-value-added movement and eliminate unnecessary interruptions. By structurally eliminating inefficiencies and establishing an accurate line balance efficiency (LBE) baseline, this line-design phase alone can deliver meaningful sewing efficiency gains—on the order of several percentage points—from early in the ramp.

Phase 2: Ramp-up

Once a line is fundamentally balanced, the ramp-up phase focuses on rapidly accelerating production volume for new styles. When specific bottleneck stations are identified, interventions must be highly tactical. IE teams conduct targeted work studies to optimize tasks—for instance, redesigning a segmented, two-step sewing motion into a single continuous action, or calibrating sewing machine speeds to match the operator’s rhythm. This is reinforced by intensive speed training, utilizing video recordings of top-performing operators to rapidly cross-train peers. These practical speed-training interventions can drive an additional few percent in sewing efficiency improvement over the initial weeks.

Phase 3: Line management

The ultimate determinant of sustained performance is daily line management. In this phase, a digital manufacturing execution system (MES) becomes the standard operational backbone for shop floor control. By replacing retrospective paper charts with real-time visual boards that track hourly output and defect rates, supervisors are empowered to conduct immediate, on-the-spot debottlenecking.

Furthermore, consistent flow requires disciplined “pace making.” Interestingly, a counterintuitive phenomenon often emerges following the initial speed training: While operators acquire the capability to execute tasks much faster, they often do not sustain that pace in production, leaving overall throughput below potential. To resolve this, engineers regulate the rhythm at key points on the line, keeping the pace steady and controlling WIP so that material does not build up and disconnect downstream operators. As the line stabilizes, operators are given frequent, granular output feedback, allowing them to self-regulate and pace one another—maintaining steady throughput without constant supervision.

When manufacturers fully commit to this three-phased operational recipe—combining rigorous line design, rapid ramp-up, and system-driven line management—total sewing efficiency typically improves by 10 to 15 percent. Importantly, these gains are not one-offs; they create the stable operating foundation required for digital and automation initiatives to deliver ongoing productivity improvements. Ultimately, operational excellence is the prerequisite that enables the entire system-led factory to scale effectively.

In textiles, operational excellence is now a yield, energy, throughput, quality, and service game. The real productivity prize sits in losses mills have historically absorbed as “process complexity”: cotton-specification drift and overengineered yarn strength in spinning; chronic breakage and speed loss in weaving; and reprocessing in dyeing and finishing driven by shade-off, un-levelness, and inconsistent outcomes. The winners are already running textile operations as one performance system across the value chain—with tight raw-material governance upstream, disciplined daily loss management in weaving, and first-time-right control in wet processing. Done well, this can unlock 5 to 6 percent cost improvements and meaningful throughput gains from existing assets.

Energy optimization: A major, underexploited value pool

Energy is one of the largest cost drivers in textile manufacturing, yet it remains significantly under-optimized in many operations.

Processes such as dyeing, drying, and finishing are inherently energy-intensive, relying heavily on steam generation, thermal exchange, and controlled temperature cycles. In many factories, these systems have been designed incrementally over time, resulting in fragmented energy flows, suboptimal heat utilization, and significant losses across the process chain. This creates substantial opportunities for cost reduction and operational improvement.

And energy optimization is not just a cost lever—it is increasingly a strategic necessity. Regulatory pressures, sustainability commitments, and geopolitical risks affecting energy supply are elevating energy management to a core component of manufacturing strategy. Companies that fail to optimize energy systems risk not only higher costs, but also reduced competitiveness in markets where sustainability performance is becoming a crucial sourcing criterion.

Leading manufacturers are increasingly approaching energy not as a stand-alone utility function, but as an integrated part of process optimization. They are redesigning thermal systems, improving heat recovery, and aligning energy consumption with production dynamics.

A key lever is the deployment of industrial heat recovery systems. In dyeing processes, large amounts of thermal energy are released in wastewater and exhaust streams. By capturing and reusing this energy, manufacturers can significantly reduce steam demand and fuel consumption. Heat exchangers and closed-loop recovery systems are particularly effective in stabilizing temperature profiles while lowering overall energy input.

Industrial heat pumps represent another high-impact solution. These systems upgrade low-grade waste heat to usable process temperatures, effectively reducing the need for external steam generation. In dyeing operations, heat pumps can replace a substantial portion of conventional boilers, delivering annual savings in the range of \$1 million to \$3 million per site, with typical payback periods of less than two years.

In parallel, process optimization plays a critical role. Adjustments to loading ratios, bath temperatures, dwell times, and machine utilization can reduce unnecessary heating and cooling cycles. For example, optimizing batch sequencing and increasing machine loading efficiency can significantly reduce energy consumption per unit of output, without additional capital investment. Digital and AI systems are enabling tighter performance management and faster issue resolution on key heat consumers such as dryers.

Electrification and renewable integration further enhance the impact. The use of electric boilers in combination with onsite solar generation allows manufacturers to reduce dependency on fossil fuels while stabilizing energy costs. In several cases, solar integration has generated incremental savings of approximately \$500,000 to \$1 million per site annually, while also improving resilience to energy price volatility.

When approached holistically—combining heat recovery, process optimization, electrification, and renewable integration—energy initiatives can deliver cost reductions exceeding 30 percent, while simultaneously improving operational stability and environmental performance.

From improvement to integrated transformation

The greatest value is realized not by applying these levers independently, but by integrating them into a coherent transformation. Individually, each lever delivers incremental improvements. Digital enhances visibility and decision-making. Automation increases productivity and reduces labor dependency. Operational excellence stabilizes processes and reduces variability. Energy optimization lowers cost and improves resilience.

The true step change occurs, however, when these levers are applied simultaneously and aligned at the process level—operating as one integrated system. In such a model, digital systems provide real-time visibility and decision support; automation executes standardized processes with minimal variability; operational excellence ensures stability and consistency across the value stream; and energy systems are optimized in line with production dynamics.

This integrated approach fundamentally changes how factories operate. Planning becomes dynamic and data driven. Execution becomes standardized and repeatable, and variability is reduced at the source rather than managed downstream.

In practice, this translates to a different performance trajectory. Rather than incremental improvements of a few percentage points, integrated transformations consistently deliver structural gains. Across multiple implementations, manufacturers have unlocked more than \$10 million in savings per site, alongside productivity improvements exceeding 30 percent and workforce optimization above 25 percent.

Importantly, these gains are not limited to cost. Factories operating under a system-led model demonstrate faster ramp-up for new styles, higher adherence to delivery commitments, and significantly reduced operational volatility. Performance becomes more predictable, more scalable, and less dependent on local conditions.

For global manufacturers, the impact compounds across networks. Standardized systems and processes can be replicated across factories, enabling consistent performance and reducing the complexity of managing distributed production.

The textile and apparel manufacturing industries are undergoing a structural transformation. The traditional model—labor-intensive, craftsmanship-driven, and incrementally improved—is no longer sufficient to compete in an environment defined by volatility, cost pressure, and increasing complexity.

The factory of the future will be defined by how well its integrated systems perform. In this new model, processes replace improvisation, data replaces guesswork, and systems help workers perform at high and stable levels of quality and productivity. Production teams operate in more advanced, semiautomated environments, delivering higher consistency, faster ramp-up, and more predictable performance. Cost leadership will increasingly be determined by system design, not labor cost.

Manufacturers that embrace this shift will not only improve margins, but also build more resilient, scalable, and future-proof operations. Those that do not risk structural disadvantage in an increasingly system-driven industry.

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