Advanced Decision Intelligence for Financial and Operational Resilience in Saudi Pharmaceutical Manufacturing under Vision 2030: Integrating SAP S/4HANA, Power BI, Predictive Forecasting and Working-Capital Analytics

Abstract:

Saudi pharmaceutical manufacturing is being asked to localise more value, protect medicine availability and improve productivity while operating under demand volatility, imported-input exposure, strict quality controls and cash tied up in inventory and receivables. This review develops an integrated decision-intelligence model for connecting enterprise transactions with predictive and financial analytics. It focuses on four complementary capabilities: SAP S/4HANA as the governed transactional backbone; Power BI as a role-based visual decision layer; predictive forecasting as an anticipatory mechanism for demand, supply and production variability; and working-capital analytics as the financial discipline linking resilience choices to liquidity. A structured integrative review of 30 sources published between 2020 and 2025 was synthesised through thematic coding, comparative analysis and evidence-quality appraisal. The synthesis shows that resilience does not arise from technology adoption alone. It depends on a closed decision loop in which reliable master and transactional data are converted into forecasts, exceptions, scenarios, managerial actions and measurable learning. For pharmaceutical plants, the highest-value integration points are demand and inventory planning, supplier risk, production and quality execution, expiry exposure, receivables, payables and cash-conversion management. The paper proposes a decision-intelligence architecture and maturity pathway tailored to Saudi manufacturing conditions under Vision 2030. The model clarifies how operational continuity and financial resilience can be managed jointly rather than as separate agendas, while preserving traceability, governance and human accountability.

Keywords: decision intelligence; pharmaceutical manufacturing; Saudi Arabia; SAP S/4HANA; Power BI; predictive forecasting; working capital; operational resilience

1. Introduction

Pharmaceutical manufacturing combines characteristics that make resilience unusually difficult to manage. Demand can change abruptly because of epidemiological shifts, tenders, treatment protocols and substitution effects, while supply depends on active pharmaceutical ingredients, excipients, packaging, specialist equipment and qualified vendors that may sit across several countries. Production cannot simply respond by increasing output because batch release, laboratory testing, validation, stability requirements and controlled change constrain speed. At the same time, excessive defensive inventory can immobilise cash and create expiry or obsolescence exposure. Resilience therefore has two inseparable dimensions: the ability to sustain safe product availability and the ability to preserve liquidity, margins and investment capacity while doing so. Research on organisational and supply-chain resilience increasingly treats anticipation, adaptation, recovery and learning as connected capabilities rather than a single recovery event [2-4]. Digital transformation can strengthen these capabilities when it improves visibility, coordination and decision speed instead of merely automating isolated tasks [1,7-9].

Saudi Arabia adds a strategic context to this challenge. Vision 2030 has made industrial diversification, local capability development and a stronger private-sector contribution central to economic transformation. Pharmaceutical and health-related manufacturing is especially important because localisation can support security of supply, skilled employment and technology transfer. Saudi policy and investment activity has encouraged local production partnerships, while regulatory oversight continues to require strong manufacturing and quality discipline [6,11,15]. For manufacturers, the implication is that resilience cannot be designed only around global procurement. It must also include localisation choices, supplier development, data governance, workforce capability, capacity economics and the financial consequences of carrying buffers or accelerating domestic production.

The literature provides strong but fragmented evidence. Enterprise systems research explains how integrated digital platforms can reduce information latency and connect functions [1,16,20,21]. Supply-chain research demonstrates that visibility, analytics and digital integration strengthen disruption preparedness and performance, particularly in dynamic environments [8,9,12,13,17-19,23-25]. Pharmaceutical studies show the value of predictive, optimisation and dashboard approaches for planning and disruption management [26,27,29]. Working-capital research, meanwhile, shows that operational risk and liquidity management are interdependent: inventory, receivables and payables are not passive accounting balances but operational resources whose configuration changes resilience [28,30]. What is less developed is a unified model that joins these streams at the decision level for Saudi pharmaceutical manufacturing.

This review addresses that gap by treating decision intelligence as an operating capability rather than a software category. Decision intelligence is defined here as the disciplined combination of governed enterprise data, analytical models, visual decision support, managerial judgement and feedback mechanisms used to improve recurring operational and financial choices. The aim is to explain how SAP S/4HANA, Power BI, predictive forecasting and working-capital analytics can be integrated into one resilience architecture for Saudi pharmaceutical manufacturers. Four objectives guide the synthesis: first, to identify the decision roles of each technology and analytical capability; second, to map the operational and financial mechanisms through which integration affects resilience;

third, to identify Saudi-specific governance, localisation and capability conditions that shape implementation; and fourth, to propose a maturity pathway linking data foundations to adaptive decision-making. The review asks how transactional integration becomes decision advantage, which measures connect operational continuity with liquidity, and what organisational controls are required to prevent analytically sophisticated but operationally weak decisions.

2. Review Methodology

A structured integrative review design was used because the research question spans information systems, operations management, supply-chain resilience, pharmaceutical manufacturing and corporate finance. A narrowly technical review would miss the organisational and financial mechanisms through which analytics changes resilience, while a broad narrative approach would make evidence selection difficult to reproduce. The protocol therefore combined bounded searching, explicit eligibility rules, thematic coding and comparative synthesis. The structure follows the analytical logic used in recent manufacturing reviews that combine descriptive, content, thematic and cross-context analysis to build an integrated conceptual framework rather than simply catalogue technologies [23].

The evidence window was restricted to 2020-2025 to reflect current digital architectures, post-pandemic resilience research and contemporary Saudi industrial transformation. Search concepts were grouped into five domains: enterprise integration (ERP, SAP S/4HANA, SAP HANA, digital supply chain); analytics and visualisation (Power BI, business intelligence, dashboards, big-data analytics); anticipation (predictive forecasting, machine learning, scenario analytics); resilience (supply-chain resilience, operational continuity, disruption management, pharmaceutical supply); and finance (working capital, cash conversion, inventory finance, receivables, payables). Saudi Arabia, GCC, Vision 2030 and pharmaceutical manufacturing terms were used to identify contextual evidence. Sources were eligible when they addressed at least two domains or provided direct sectoral or national relevance. Older conceptual references were deliberately excluded to maintain the requested date boundary.

Thirty high-relevance sources formed the final evidence base. Peer-reviewed journal articles were prioritised, with two Saudi institutional sources retained because they provide direct evidence on regulatory inspection and localisation-oriented investment activity. Quality appraisal considered clarity of the research question, methodological transparency, relevance to manufacturing or supply chains, explicitness of analytical constructs, and transferability to pharmaceutical or Saudi settings. Evidence was coded under seven categories: data foundation, visibility, prediction, decision orchestration, operational response, financial response and institutional context. Coding also distinguished leading indicators, such as forecast error and supplier lead-time variance, from lagging outcomes, such as service loss, write-offs or cash-conversion deterioration.

Synthesis proceeded in three stages. First, within-domain findings were compared to identify consistent mechanisms, contradictory claims and boundary conditions. Second, cross-domain linkages were traced; for example, demand forecast error was linked not only to service risk but also to safety stock, expiry exposure, capacity utilisation and cash tied in inventory. Third, the linked mechanisms were translated into an architecture and maturity model suitable for pharmaceutical operations. No pooled effect size was calculated because the evidence includes conceptual studies, empirical surveys, case research, optimisation models and sector reviews with heterogeneous measures. The objective is explanatory integration rather than statistical aggregation. This choice also avoids false precision: decision-intelligence value is highly contingent on data quality, process discipline, organisational incentives and regulatory constraints [3,17,24].

3. Integrated Decision Intelligence for Pharmaceutical Manufacturing

The central proposition of this review is that resilience improves when data, prediction and financial consequences are joined inside the same decision cycle. Fragmented digitalisation creates local efficiency but often transfers risk between functions. Procurement may secure lower unit prices by buying larger quantities while finance absorbs higher inventory days; production may maximise campaign efficiency while commercial teams face poor mix availability; finance may reduce working capital by cutting buffers while operations become more vulnerable to long lead-time disruptions. Digital supply-chain research repeatedly shows that integration and end-to-end visibility are essential because isolated optimisation can amplify network risk [7-9,16,19]. An effective architecture must therefore connect transaction truth, analytical interpretation, predictive foresight and accountable action.

SAP S/4HANA is positioned as the transactional and process backbone. Its value in this model is not the brand name but the integration principle: procurement, material movements, production orders, quality-relevant records, sales, receivables, payables and financial postings are represented through consistent objects and timing. ERP research shows that digital transformation yields stronger performance when technology is embedded in integrated processes rather than deployed as disconnected tools [1,20]. Studies involving SAP HANA environments further illustrate how in-memory platforms can support faster data access and adaptive supply-chain use cases [21]. For a pharmaceutical manufacturer, the practical resilience benefit is a shared record of what has been ordered, received, consumed, produced, released, sold, invoiced and paid. This reduces reconciliation latency during disruptions and makes it possible to trace operational exceptions to their financial consequences.

Yet transaction integration alone does not create decision intelligence. ERP screens are designed primarily to execute and control transactions, whereas managers need comparative patterns, exceptions, trends and scenarios. Power BI can serve as a governed decision-visualisation layer when it is connected to validated enterprise data and designed around specific decisions. Research on real-time supply-chain dashboards demonstrates that visual analytics can shorten the path from dispersed data to coordinated action [22]. A pharmaceutical case study using a rolling forecasting framework in Power BI likewise shows how visualisation can support forward-looking management rather than static reporting [27]. The critical design principle is role specificity: a plant manager should see schedule adherence, yield, quality holds and constraint risk; procurement should see supplier performance, lead-time variance and purchase exposure; finance should see inventory days, receivable ageing, payable timing and cash forecasts; executives should see integrated service, margin, cash and risk trade-offs.

Predictive forecasting adds the anticipatory layer. Resilience studies consistently find that analytics contributes most when it allows organisations to detect change early, explore consequences and reconfigure resources before disruption becomes loss [12,13,17,24]. In pharmaceuticals, predictive use cases extend beyond demand forecasting. Models can estimate supplier delay probability, material shortage risk, batch cycle-time variability, quality deviation likelihood, inventory expiry, receivable collection timing and near-term cash requirements. Pharmaceutical supply-chain research increasingly uses optimisation and predictive analytics to examine multi-objective disruption management [26,29]. The value is not a single more accurate forecast; it is a portfolio of probabilistic signals that changes the timing of managerial intervention.

Forecast quality must nevertheless be governed carefully. Models trained on stable historical relationships can fail when policy, tendering, disease patterns, competitor availability or sourcing structures change. Advanced analytics research warns that capability value depends on data quality, organisational learning and the ability to interpret models under changing conditions [13,17,25]. The decision process should therefore separate forecast generation from forecast acceptance. Statistical or machine-learning predictions should be accompanied by confidence ranges, error histories, driver explanations and override documentation. Human judgement remains essential where regulatory, clinical, contractual or market information has not yet appeared in historical data. The appropriate objective is not automation for its own sake but calibrated anticipation.

Working-capital analytics provides the financial control layer that is often missing from resilience discussions. Supply disruption and working capital are connected through inventory buffers, purchasing terms, emergency freight, production inefficiency, delayed sales, receivable collection and supplier payment. Recent evidence shows that supply-chain risk materially influences working-capital choices [28], while AI-supported financial analytics can reveal context-dependent working-capital strategies rather than one universal optimum [30]. In pharmaceutical manufacturing, inventory is particularly significant because the same buffer can simultaneously protect service and increase expiry, storage and cash costs. Decision intelligence should therefore evaluate resilience investments in cash terms, not only operational terms.

The most useful working-capital measures are decision-linked rather than purely accounting-based. Days inventory outstanding should be decomposed by raw materials, work in process, quality-held stock and released finished goods. Receivable days should be analysed by customer segment, tender or channel, dispute status and payment probability. Payable days should be considered alongside supplier criticality, early-payment economics and continuity risk. Cash-conversion cycle should be complemented by projected liquidity under demand, delay and inventory scenarios. This changes working-capital management from retrospective treasury reporting into an operational design variable. It also prevents the false choice between resilience and efficiency: some buffers create economic option value, while others merely hide planning errors or slow-moving stock.

Figure 1 expresses the integrated architecture. Enterprise transactions form the governed foundation; a semantic and master-data layer aligns definitions; predictive services transform data into forward-looking signals; Power BI presents role-specific decision views; and workflow actions feed execution back into ERP. The outer loop captures outcomes such as service continuity, release reliability, margin protection, cash conversion and localisation progress. The architecture is intentionally closed-loop. Dashboards without execution pathways create observation, not resilience. Forecasts without post-decision learning create repeated bias. Financial metrics without operational causality encourage indiscriminate cost cutting. Integration matters because each layer corrects a weakness in the others.

Table 1. Decision roles of the integrated technology and analytics stack.

Capability	Primary decision role	Representative data	Resilience contribution	Principal governance risk
SAP S/4HANA	Transaction truth and process execution	Purchase orders, inventory, production, sales, AR/AP, financial postings	Shared state, traceability, faster cross-functional coordination	Poor master data or inconsistent process discipline
Power BI	Role-specific visual decision support	Governed semantic measures, trends, exceptions, drill-through detail	Shorter detection-to-action time; common management view	Competing KPI definitions or uncontrolled extracts
Predictive forecasting	Estimate future demand, supply, production and	History, drivers, lead times, quality and market signals	Earlier intervention and scenario preparation	Model drift, bias, weak explainability or

	cash states			over-automation
Working-capital analytics	Translate operational choices into liquidity and capital effects	Inventory, receivables, payables, payment terms, cash forecasts	Liquidity protection and risk-adjusted buffer decisions	Cost minimisation that weakens continuity

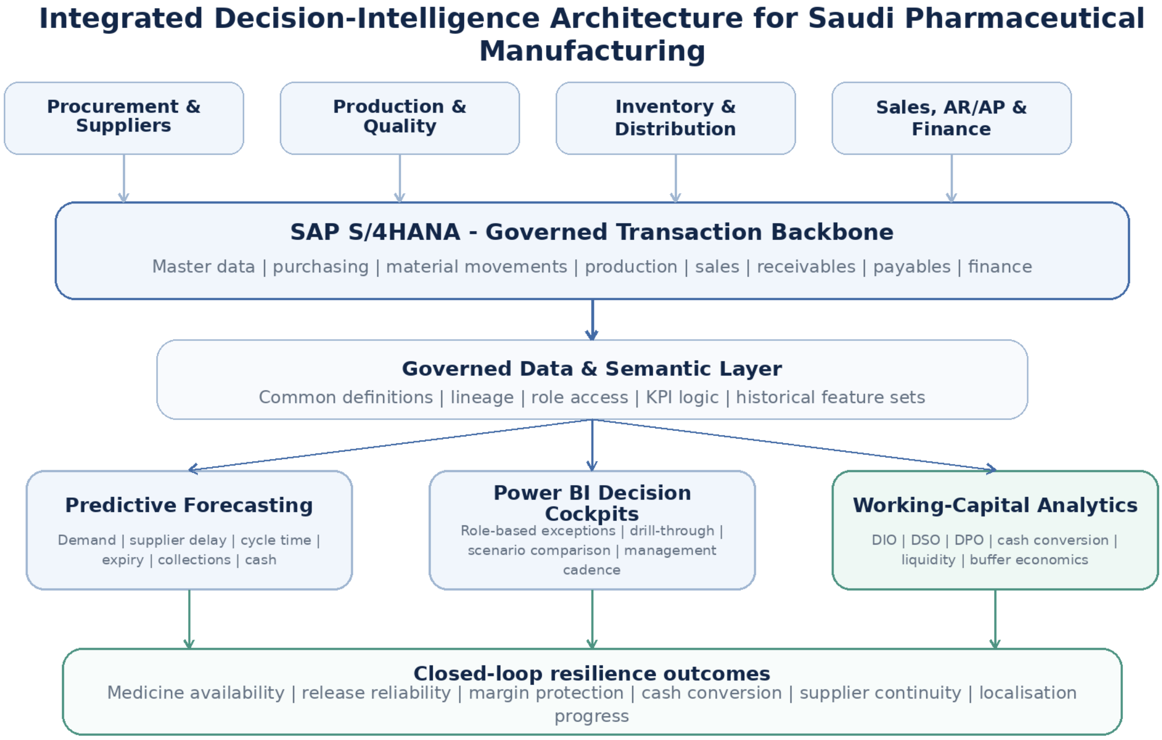

Figure 1. Integrated decision-intelligence architecture linking enterprise transactions, governed analytics, predictive forecasting and working-capital decision support.

4. Financial and Operational Resilience Mechanisms

Demand and inventory planning is the first mechanism through which integrated decision intelligence creates resilience. Forecast error in pharmaceuticals propagates quickly: under-forecasting can produce shortages, expedited procurement and lost sales, whereas over-forecasting can create excess stock, expiry and cash absorption. Digital resilience research shows that visibility and predictive capability help organisations move from reactive replenishment to anticipatory configuration [9,12,17]. The decision objective should therefore be service-risk-adjusted inventory, not minimum inventory. Forecast distributions can be combined with lead-time variability, shelf-life constraints, batch sizes and service targets to identify where additional stock has genuine protective value. Power BI can then expose exceptions such as high-value slow movers, short-dated stock, forecast bias and material positions below time-phased coverage thresholds.

Supplier and procurement resilience is the second mechanism. Pharmaceutical production may depend on single or highly qualified sources, so procurement risk cannot be inferred from spend alone. A low-cost material may be operationally critical if substitution requires regulatory or quality approval. Integrated analytics should combine supplier lead-time variance, delivery reliability, quality rejection, geographic concentration, contractual terms, open purchase orders and financial exposure. Research on digital supply chains and resilience shows that integration, visibility and analytics improve response to network disruptions [8,9,18,24]. A useful decision rule is to classify suppliers by both economic and continuity criticality, then link that classification to buffer policy, dual-source development, payment strategy and executive escalation.

Production and quality resilience forms the third mechanism. In regulated manufacturing, capacity is not simply installed equipment time; it is qualified, schedulable and releasable capacity. A batch occupying a line can still fail to create saleable inventory because of yield loss, deviation, laboratory delay or release hold. Decision intelligence should therefore connect production-order performance with material genealogy, quality status, queue time, yield, rework and cost variance. Predictive models can identify patterns associated with extended cycle times or constraint formation, while dashboards can prioritise orders based on service and cash impact. Pharmaceutical optimisation research demonstrates the importance of multi-objective disruption management rather than single-metric efficiency [26]. The integrated objective is to protect reliable output while avoiding actions that merely shift bottlenecks to quality, warehousing or cash.

Working-capital and liquidity resilience is the fourth mechanism. Operational shocks alter cash timing before they appear in profit. A supplier delay may trigger advance purchases elsewhere; a quality hold postpones invoicing; a demand decline leaves finished inventory unsold; a customer dispute extends receivable ageing. Working-capital analytics should therefore be scenario-based. Huynh and Le link supply-chain risk with working-capital management choices [28], while newer AI-oriented finance research demonstrates the value of data-driven strategy differentiation [30]. The pharmaceutical manufacturer can model cash consequences of alternative buffer levels, sourcing choices, production campaigns and collection assumptions. This creates a common language between finance and operations: decisions are evaluated through expected service protection, downside exposure, cash requirement and recovery time.

Table 2 translates these mechanisms into a compact resilience scorecard. The purpose of the scorecard is not to create more indicators but to connect each indicator with a decision trigger. Forecast accuracy matters only if error bands change inventory, capacity or commercial action. Inventory days matter only if stock is segmented by service role and expiry risk. Overall equipment effectiveness is insufficient if quality release remains the true constraint. Receivable ageing is incomplete if dispute probability and customer criticality are ignored. The combined scorecard therefore mixes leading and lagging measures and forces cross-functional interpretation. Resilience becomes observable as the organisation's ability to keep critical outcomes within tolerances while shocks change underlying assumptions.

Table 2. Integrated financial and operational resilience scorecard.

Decision domain	Core indicator	Analytical interpretation	Managerial trigger
Demand & inventory	Forecast error/bias; days of cover; expiry exposure; DIO	Service protection versus excess and cash absorption	Rebalance forecast, safety stock, production or allocation
Supply	Lead-time variance; OTIF; quality rejection; source concentration	Probability and consequence of material disruption	Expedite, dual-source, pre-buy, renegotiate or escalate
Production & quality	Schedule adherence; yield; cycle time; release queue; cost variance	Qualified output risk and constraint formation	Resequence, adjust campaign, investigate quality or capacity
Receivables	DSO; ageing; dispute rate; predicted collection date	Cash timing and customer concentration exposure	Collections action, credit review or commercial resolution
Payables	DPO; early-payment return; supplier criticality	Liquidity benefit versus supplier continuity economics	Time payment strategically or support critical supplier
Enterprise resilience	Cash-conversion cycle; service level; recovery time; downside cash	Joint operational-financial resilience outcome	Executive scenario decision and portfolio reallocation

5. Saudi Vision 2030 Context and Implementation Conditions

The Saudi context changes both the purpose and the governance of decision intelligence. Economic diversification policies have encouraged development of domestic industrial capabilities and reduced dependence on a narrow set of external value streams [15]. In pharmaceuticals, localisation is not simply a procurement preference; it can involve technology transfer, qualified local manufacturing, supplier ecosystem development, workforce capability and long-term investment. Saudi investment activity has included agreements supporting local production of vaccines and insulin-related capabilities [11]. A decision-intelligence model should therefore measure localisation through operational and economic evidence: local content share, qualified domestic supplier depth, time to qualify alternatives, domestic capacity utilisation, import lead-time exposure and the cash economics of local versus imported supply.

Regulatory traceability is equally important. Saudi regulatory inspection activity has emphasised manufacturing practice, laboratories, quality systems and material controls [6]. This means predictive and visual analytics must be designed around validated source data and clear accountability. A dashboard may aggregate information for speed, but it should not become an alternative system of record. Master-data ownership, access control, change logging, model versioning and data lineage are necessary to preserve trust. For sensitive decisions, users should be able to trace a KPI or forecast back to the relevant transaction population and definition. This is especially important when operational decisions affect product quality, batch release, supplier qualification or regulatory commitments.

Workforce capability is another boundary condition. Research on resilience and digital transformation repeatedly shows that technology creates value through organisational capabilities, not substitution for them [3,18,23,25]. Saudi manufacturers may have different levels of analytical maturity across finance, supply chain, production and quality. A technically elegant model can therefore fail if planners do not understand probabilistic forecasts, managers interpret dashboards inconsistently or functions are rewarded for conflicting local targets. Implementation should begin with decision rights: who owns the forecast, who can override it, who approves buffer changes, who decides supplier escalation, and who accepts cash-versus-service trade-offs. Training should combine data literacy with process and financial literacy so that users understand both operational causes and economic consequences.

Data architecture also requires deliberate simplification. Resilience dashboards often become overloaded because every function requests its existing KPIs. The proposed model instead starts from a limited set of high-consequence decisions and works backwards to required data. For example, the decision to pre-buy a critical imported material requires current stock, shelf life, open purchase orders, forecast distribution, supplier lead time, quality risk, unit value, storage constraints and cash impact. If one of those elements is unavailable or unreliable, the analytical confidence should be made visible. This approach prevents false precision and helps prioritise master-data remediation. It also supports phased implementation: visibility first, then predictive analytics, then scenario optimisation and adaptive decision rules.

The implementation case should finally be evaluated as a portfolio rather than a sequence of software projects. ERP enhancement, semantic modelling, dashboard development, forecasting and working-capital analytics share data and governance dependencies. Treating them separately can produce duplicate models and conflicting definitions. A portfolio roadmap should prioritise use cases by resilience impact, financial materiality, data readiness and implementation risk. Early use cases may include demand and inventory exception management because they connect service, expiry and cash; supplier-risk views because they support localisation and continuity; and integrated cash forecasting because it exposes the financial consequences of operational volatility. More autonomous optimisation should follow only after data definitions, decision ownership and feedback routines have stabilised.

6. Decision-Intelligence Maturity and Closed-Loop Operating Model

A maturity pathway is useful because organisations rarely move directly from fragmented reporting to adaptive decision-making. The first stage is fragmented visibility, where functions maintain separate extracts, assumptions and reconciliations. The second stage is governed integration, in which core master data, transaction definitions and KPI logic are aligned around SAP S/4HANA and an enterprise analytical model. The third stage is predictive control, where forecast models and exception thresholds anticipate demand, supply, production, quality and cash movements. The fourth stage is scenario-based orchestration, where managers compare alternatives across service, margin, working capital and risk. The fifth stage is adaptive learning, where forecast errors, overrides, incidents and outcomes systematically update models, policies and decision rules.

Figure 2 represents the operating loop as Sense, Predict, Prioritise, Decide, Execute and Learn. The loop is deliberately cross-functional. 'Sense' consolidates transactional and external signals; 'Predict' estimates likely future states and uncertainty; 'Prioritise' ranks issues by patient-service, operational, financial and regulatory consequence; 'Decide' selects an intervention with explicit trade-offs; 'Execute' routes approved action into purchasing, planning, production, quality, sales or finance processes; and 'Learn' compares expected and realised outcomes. This design reflects evidence that resilience depends on dynamic capabilities and organisational learning rather than static buffers [3,7,18]. It also prevents a common failure mode in business intelligence: dashboards become reporting destinations instead of components of an operating system.

Maturity should be assessed through evidence of decision behaviour, not feature deployment. An organisation is not predictive merely because it owns a forecasting model, nor integrated because it has an ERP. Progress is demonstrated when the same definitions are used across functions, exceptions are acted upon within agreed times, overrides are recorded with reasons, cash and service consequences are evaluated together, and post-event learning changes future parameters. The maturity model therefore treats technology as necessary infrastructure but places decision discipline at the centre.

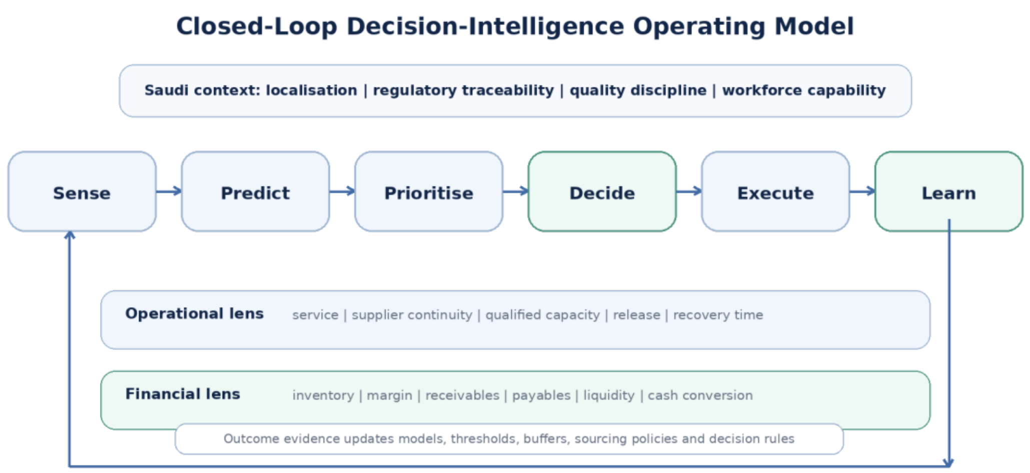

Figure 2. Closed-loop operating model joining operational and financial lenses within Saudi localisation and regulatory conditions.

7. Discussion

The synthesis produces three main insights. First, financial resilience and operational resilience are not parallel outcomes; they are coupled through working capital. Inventory, supplier terms, quality holds, production timing and collections create a cash representation of operational design. Second, predictive analytics creates value only when it is connected to decision rights and execution. Accuracy without action latency reduction has limited resilience value. Third, Saudi localisation objectives create an additional decision dimension: short-term cost comparisons should be balanced against continuity, capability development and strategic dependence. These insights extend digital-resilience research by making the cash-conversion mechanism explicit and by locating decision intelligence between technology capability and realised resilience [12,13,19,25].

A further implication concerns the design of managerial attention. Pharmaceutical organisations generate far more data than managers can interpret continuously, so decision intelligence must reduce, not increase, cognitive load. The architecture should distinguish routine variation from material exceptions and rank exceptions according to consequence, urgency and controllability. A forecast deviation for a low-value, substitutable item is not equivalent to the same percentage deviation for a sole-sourced critical medicine. Likewise, a temporary increase in inventory may be rational when it protects a validated production campaign, whereas the same increase may be destructive when caused by demand bias or delayed quality release. This consequence-based prioritisation links the literature on dynamic capabilities with working-capital economics. It also suggests that resilience performance should be evaluated through decision quality: whether the organisation identified the right issue early, selected a response consistent with service and cash tolerances, executed it within the available response window, and learned from the result. Such an approach moves measurement beyond static

KPI achievement. It can explain why two plants with similar inventory levels or forecast accuracy may exhibit very different resilience when disruption occurs. One may hold inventory strategically, with clear triggers and recovery rules; another may accumulate stock because planning parameters are stale. The analytical system must reveal that difference. For Saudi pharmaceutical manufacturers, this distinction is particularly important as localisation programmes can change lead times, minimum order quantities, supplier development costs and qualification risks. Decision models should therefore compare transitional states, not assume that a newly localised supply configuration immediately behaves like a mature one. During supplier qualification or technology transfer, management may accept temporarily higher cost or working capital in exchange for a measurable reduction in strategic dependence. Once local capability stabilises, the same model should tighten inventory, payment and capacity parameters. In this sense, advanced decision intelligence is not a search for a permanently optimal configuration; it is a controlled method for changing the configuration as evidence, capability and risk evolve. This adaptive discipline also provides executives with a transparent rationale for capital allocation across resilience, localisation and productivity initiatives.

For managers, the implication is to avoid technology-first roadmaps. The sequence should begin with decisions and material risks, then define measures, data, predictive methods and visualisation. Finance should participate from the start because resilience choices alter liquidity and capital allocation. Quality and regulatory functions should participate because some apparently attractive operational responses may be infeasible under controlled manufacturing requirements. The strongest governance model is therefore cross-functional: central standards for data, models and KPI definitions combined with local ownership of actions and learning.

The review has limitations. The evidence base intentionally spans heterogeneous methods and sectors, so causal effect sizes cannot be generalised to every pharmaceutical plant. Direct studies integrating all four focal capabilities in Saudi pharmaceutical manufacturing remain scarce. Several findings are therefore transferred from adjacent manufacturing, supply-chain and finance contexts. The rapid evolution of analytics also means implementation practice can move faster than peer-reviewed evidence. These limitations strengthen the case for plant-level longitudinal evaluation rather than weaken the conceptual integration proposed here.

8. Future Research

Future research should test the proposed architecture using longitudinal data from Saudi pharmaceutical manufacturers. Priority questions include whether joint operational-financial forecasting improves cash and service outcomes more than separate planning, how model overrides affect forecast learning, which localisation indicators predict disruption recovery, and how regulatory traceability changes the design of AI-supported decisions. Comparative studies across plants with different product portfolios and sourcing dependence would help identify which maturity stages deliver the greatest marginal resilience benefit.

9. Conclusion

Advanced decision intelligence can strengthen Saudi pharmaceutical manufacturing when it connects enterprise transaction truth, visual management, predictive foresight and working-capital discipline inside one accountable operating loop. SAP S/4HANA provides the integrated process foundation; Power BI can translate governed data into role-specific decision views; predictive forecasting anticipates demand, supply, production and cash variability; and working-capital analytics makes the liquidity consequences of resilience choices explicit. The principal contribution of this review is therefore not another technology stack, but a decision architecture linking operational continuity with financial resilience under Vision 2030. Manufacturers should progress from governed visibility to prediction, scenario orchestration and adaptive learning, while preserving regulatory traceability and human accountability. Resilience is achieved when the organisation can detect change early, choose economically defensible responses, execute them through controlled processes and learn fast enough to improve the next decision.

Main-text word count: 4,400 (abstract through conclusion; excluding title, headings, keywords, tables, figure captions and references).

References

1. Nasiri, M.; Ukko, J.; Saunila, M.; Rantala, T. Managing the digital supply chain: The role of smart technologies. Technovation 2020, 96, 102121.
2. Sarkis, J. Supply chain sustainability: Learning from the COVID-19 pandemic. International Journal of Operations & Production Management 2020, 41, 63-73.
3. Duchek, S. Organizational resilience: A capability-based conceptualization. Business Research 2020, 13, 215-246.
4. Han, Y.; Chong, W.K.; Li, D. A systematic literature review of the capabilities and performance metrics of supply chain resilience. International Journal of Production Research 2020, 58, 4541-4566.
5. Liu, Y.; Zhu, Q.; Seuring, S. New technologies in operations and supply chains: Implications for sustainability. International Journal of Production Economics 2020, 229, 107889.
6. Saudi Food and Drug Authority. SFDA Inspects 124 Pharmaceutical Manufacturers During 2020 and Reports Manufacturing, Laboratory, Quality-System and Material Observations. Riyadh, 2020.
7. Zouari, D.; Ruel, S.; Viale, L. Does digitalising the supply chain contribute to its resilience? International Journal of Physical Distribution & Logistics Management 2021, 51, 149-180.

8. Belhadi, A.; Kamble, S.; Jabbour, C.J.C.; Gunasekaran, A.; Ndubisi, N.O.; Venkatesh, M. Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries. Technological Forecasting and Social Change 2021, 163, 120447.

9. Ivanov, D. Digital supply chain management and technology to enhance resilience by building and using end-to-end visibility during the COVID-19 pandemic. IEEE Transactions on Engineering Management 2021, 71, 10485-10495.

10. Durugbo, C.M.; Amoudi, O.; Al-Balushi, Z.; Anouze, A.L. Wisdom from Arabian networks: A review and theory of regional supply chain management. Production Planning & Control 2021, 32, 1265-1281.

11. Ministry of Investment of Saudi Arabia. Investment Highlights: H2 2021. Riyadh, 2021.

12. Qader, G.; Junaid, M.; Abbas, Q.; Mubarik, M.S. Industry 4.0 enables supply chain resilience and supply chain performance. Technological Forecasting and Social Change 2022, 185, 122026.

13. Bahrami, M.; Shokouhyar, S. The role of big data analytics capabilities in bolstering supply chain resilience and firm performance: A dynamic capability view. Information Technology & People 2022, 35, 1621-1651.

14. Wang, L.; Deng, T.; Shen, Z.J.M.; Hu, H.; Qi, Y. Digital twin-driven smart supply chain. Frontiers of Engineering Management 2022, 9, 56-70.

15. Al Naimi, S.M. Economic diversification trends in the Gulf: The case of Saudi Arabia. Circular Economy and Sustainability 2022, 2, 221-230.

16. Perano, M.; Cammarano, A.; Varriale, V.; Del Regno, C.; Michelino, F.; Caputo, M. Embracing supply chain digitalization and unphysicalization to enhance supply chain performance: A conceptual framework. International Journal of Physical Distribution & Logistics Management 2023, 53, 628-659.

17. Zamani, E.D.; Smyth, C.; Gupta, S.; Dennehy, D. Artificial intelligence and big data analytics for supply chain resilience: A systematic literature review. Annals of Operations Research 2023, 327, 605-632.

18. Spieske, A.; Gebhardt, M.; Kopyto, M.; Birkel, H.; Hartmann, E. The future of Industry 4.0 and supply chain resilience after the COVID-19 pandemic: Empirical evidence from a Delphi study. Computers & Industrial Engineering 2023, 181, 109344.

19. Junaid, M.; Zhang, Q.; Cao, M.; Luqman, A. Nexus between technology-enabled supply chain dynamic capabilities, integration, resilience, and sustainable performance: An empirical examination of healthcare organizations. Technological Forecasting and Social Change 2023, 196, 122828.

20. Gessa, A.; Jimenez, A.; Sancha, P. Exploring ERP systems adoption in challenging times: Insights of SMEs stories. Technological Forecasting and Social Change 2023, 195, 122795.
21. Nahhas, A.; Haertel, C.; Daase, C.; Volk, M.; et al. On the integration of Google Cloud and SAP HANA for adaptive supply chain in retailing. Procedia Computer Science 2023, 217, 1857-1866.
22. Nabil, D.H.; Rahman, M.H.; Chowdhury, A.H.; Menezes, B.C. Managing supply chain performance using a real-time Microsoft Power BI dashboard by action design research method. Cogent Engineering 2023, 10, 2257924.
23. Reaidy, P.; Alaeddini, M.; Gunasekaran, A.; Lavastre, O.; Shahzad, M. Unveiling the impact of Industry 4.0 on supply chain performance: The mediating role of integration and visibility. Production Planning & Control 2024, 1-22.
24. Belhadi, A.; Mani, V.; Kamble, S.S.; Khan, S.A.R.; Verma, S. Artificial intelligence-driven innovation for enhancing supply chain resilience and performance under the effect of supply chain dynamism: An empirical investigation. Annals of Operations Research 2024, 333, 627-652.
25. Eslami, M.H.; Jafari, H.; Achtenhagen, L.; Carlback, J.; Wong, A. Financial performance and supply chain dynamic capabilities: The moderating role of Industry 4.0 technologies. International Journal of Production Research 2024, 62, 8092-8109.
26. Badejo, O.; Ierapetritou, M. Enhancing pharmaceutical supply chain resilience: A multi-objective study with disruption management. Computers & Chemical Engineering 2024, 188, 108769.
27. Belghith, M.; Ben Ammar, H.; Elloumi, A.; Hachicha, W. A new rolling forecasting framework using Microsoft Power BI for data visualization: A case study in a pharmaceutical industry. Annales Pharmaceutiques Francaises 2024, 82, 493-506.
28. Huynh, N.; Le, Q.N. From chain to capital: Supply chain risks and working capital management. Economics Letters 2025, 247, 112100.
29. Vadaga, A.K.; Dokuburra, U.R.; Nekkanti, H.; Gudla, S.S.; Kumari R, K. Digital transformation in pharmaceuticals: The impact of AI on supply chain management. Intelligent Hospital 2025, 1, 100008.
30. Akdogan, Y.E. AI-driven insights into working capital strategies: An application on Borsa Istanbul. Borsa Istanbul Review 2025, 25, 1359-1377.