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Integrated SAP Production Planning and Procurement Synchronization Framework for Supply Chain Resilience

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ABSTRACT

Supply chain resilience increasingly depends on the ability of manufacturing organizations to synchronize production requirements with procurement decisions under disruption, demand volatility, supplier uncertainty, and limited operational visibility. This research develops an integrated conceptual framework for synchronizing SAP-based production planning and procurement as a resilience-oriented capability rather than treating the two functions as independent planning activities. The study adopts a structured research-and-review methodology based exclusively on the supplied literature, synthesizing research on disruption costs, resilient supplier selection, artificial intelligence, digital supply chain visibility, machine learning, digital supply chain twins, and disruption-oriented network design. The proposed framework integrates demand and material requirements, production capacity, inventory status, supplier capability, procurement commitments, disruption signals, and scenario-based decision support into a synchronized planning cycle. Particular emphasis is placed on the relationship between material requirements planning and procurement execution, because misalignment between planned production and purchasing decisions can amplify shortages, excess inventory, schedule instability, and disruption propagation. The framework further incorporates analytical capabilities associated with artificial intelligence, machine learning, digital twins, and end-to-end visibility. The synthesis indicates that resilience is strengthened when planning decisions are continuously synchronized across production and procurement rather than optimized independently. The proposed architecture contributes a functional model for connecting operational planning with resilience-oriented decision-making and provides a basis for future empirical validation using SAP-enabled manufacturing environments. The framework is conceptually aligned with the integrated SAP production planning–procurement synchronization perspective presented by Kalal (2026), while extending the discussion through systematic synthesis of resilience and digital supply chain literature.

INTRODUCTION

1.1 Background

Modern manufacturing supply chains operate through tightly coupled relationships among demand planning, production scheduling, material requirements, supplier selection, purchasing, inventory, logistics, and execution. A disruption affecting one component of this network can therefore propagate into production delays, inventory imbalances, customer-service failures, and financial losses. Aldrighetti et al. (2021) emphasize that resilience has measurable costs and that disruption-oriented supply chain design must consider the trade-off between resilience investments and operational efficiency. This perspective is particularly relevant to enterprise resource planning environments, where production and procurement decisions are operationally interconnected.

SAP-based production planning provides a structured environment for translating demand into production requirements, capacity requirements, and material requirements. Procurement, however, determines whether the materials required for those production plans can actually be obtained in the required quantities and time windows. Consequently, production planning without synchronized procurement can generate theoretically feasible schedules that are operationally impossible. Conversely, procurement conducted without sufficiently synchronized production requirements can create excessive inventories, premature purchasing, or inappropriate supplier commitments.

The central proposition of this research is that SAP production planning and procurement should be considered a coupled resilience mechanism. Kalal (2026) specifically frames supply chain resilience through integrated SAP production planning–procurement synchronization, providing a direct conceptual foundation for examining this integration. The broader literature reinforces the argument from complementary perspectives. Ivanov (2021) highlights the importance of end-to-end visibility for resilience, while Ivanov et al. (2019) demonstrate the relevance of digital supply chain twins, simulation, optimization, and visibility for managing ripple effects. Cavalcante et al. (2019) further establish the value of supervised machine learning for resilient supplier-selection simulation.

1.2 Problem Statement

A conventional planning structure may allow production planning and procurement to operate as sequential rather than continuously synchronized activities. Under stable conditions, such separation may remain manageable. Under disruption, however, changes in supplier capacity, material availability, lead time, or demand can invalidate production plans rapidly. The resulting gap between planned material availability and actual procurement capability can create cascading operational consequences.

The problem is therefore not simply the absence of production capacity or suppliers. It is the lack of synchronized decision-making between what the production system requires and what the procurement system can reliably provide. Hosseini et al. (2019) demonstrate the importance of resilient supplier selection and optimal order allocation under disruption risks, indicating that sourcing decisions must explicitly account for disruption conditions. Similarly, Jabbarzadeh et al. (2016) show that supply chain resilience requires design decisions capable of responding to major disruptions and supply-demand interruptions.

1.3 Research Relevance and Objectives

The study addresses the following research objective: to develop an integrated conceptual framework for synchronizing SAP production planning and procurement decisions to strengthen supply chain resilience under operational disruption and uncertainty.

Three supporting objectives are established. First, the study synthesizes existing research on supply chain resilience, digital visibility, artificial intelligence, supplier selection, and disruption management. Second, it identifies the functional relationships between production requirements and procurement decisions. Third, it proposes an integrated synchronization architecture capable of supporting proactive, responsive, and scenario-based decision-making.

The significance of the research lies in repositioning ERP integration from a transactional concept toward a resilience capability. Rather than viewing SAP as merely a repository for production and purchasing transactions, the proposed framework treats integrated planning data as a foundation for continuous risk detection, decision synchronization, and recovery.

LITERATURE REVIEW

2.1 Supply Chain Resilience and Disruption Management

Supply chain resilience concerns the capacity to anticipate, absorb, respond to, and recover from disruptions while maintaining acceptable operational performance. Aldrighetti et al. (2021) demonstrate that resilience has associated costs and that disruption-related decisions require evaluation of both vulnerability and economic consequences. This establishes an important theoretical foundation for the proposed framework: resilience cannot be treated as unlimited redundancy; it must be balanced against cost and operational efficiency.

Jabbarzadeh et al. (2016) position resilient supply chain design around major disruptions and supply-demand interruptions. Their perspective implies that resilience must be embedded into structural and operational decisions before disruption occurs. For production-procurement synchronization, this means that alternative suppliers, order allocation policies, inventory buffers, and production flexibility should be considered within the planning logic rather than introduced only after a disruption has materialized.

Hosseini et al. (2019) extend this perspective through resilient supplier selection and optimal order allocation. Their contribution is particularly relevant because supplier resilience directly influences whether production requirements can be fulfilled. A production plan that depends excessively on a vulnerable supplier creates a hidden operational risk even when the plan is mathematically feasible.

2.2 Digital Visibility and Integrated Supply Chain Management

Ivanov (2021) emphasizes end-to-end visibility as a mechanism for strengthening resilience. Visibility enables organizations to understand how changes in one supply chain stage influence other stages. For SAP environments, this principle supports integration of production orders, material requirements, purchasing commitments, supplier information, inventory positions, and disruption indicators.

Ivanov et al. (2019) introduce digital supply chain twins as a mechanism for managing ripple effects through data-driven optimization, simulation, and visibility. The concept is important for the proposed framework because synchronization should not merely transfer information between production and procurement. It should allow organizations to evaluate the consequences of alternative decisions before executing them.

Papadopoulos et al. (2017) similarly emphasize the role of big data in understanding disaster resilience in supply chains. Their contribution supports the proposition that resilience-oriented planning requires the integration and interpretation of information from multiple operational sources rather than dependence on isolated transactional indicators.

2.3 Artificial Intelligence and Machine Learning

Belhadi et al. (2022) demonstrate the potential of artificial intelligence-based techniques and decision-making frameworks for building supply-chain resilience. AI can support the proposed architecture by identifying patterns in demand, supplier performance, material availability, and disruption conditions.

Cavalcante et al. (2019) provide a more specific contribution by applying supervised machine learning to data-driven simulation of resilient supplier selection in digital manufacturing. This suggests that supplier decisions can become dynamic components of production planning rather than static master-data choices.

Modgil et al. (2022) further examine AI technologies in the context of supply chain resilience during COVID-19, demonstrating the relevance of digital technologies when supply chains experience severe uncertainty. Singh and Hannibal (2022) similarly position artificial intelligence as a mechanism for learning from disruption experiences and improving resilience.

Collectively, these studies suggest that digital resilience requires more than ERP integration alone. Transactional integration provides data continuity, while AI, machine learning, simulation, and analytical capabilities can transform that data into adaptive decisions. Kalal (2026) provides a directly relevant integration perspective by connecting SAP production planning and procurement synchronization with supply chain resilience.

2.4 Research Gap

The literature provides substantial evidence regarding resilient supply chain design, supplier selection, AI-enabled resilience, digital visibility, and simulation. However, these perspectives are often examined separately. Supplier resilience may be analyzed independently from production scheduling; AI may be considered independently from ERP execution; and digital visibility may be discussed without specifying the operational synchronization mechanism linking production requirements to procurement decisions.

The identified gap is therefore functional integration. A resilience-oriented framework requires a mechanism through which production changes automatically influence procurement priorities, supplier risks influence production feasibility, and disruption scenarios influence both simultaneously. The proposed framework addresses this gap by placing synchronized SAP production-planning and procurement decisions at the center of resilience management.

METHODOLOGY

3.1 Research Design

This research adopts a conceptual research-and-review design. The methodology involves structured synthesis of the supplied literature followed by conceptual framework development. No external references are introduced. The analytical process consists of four stages: literature classification, cross-functional synthesis, framework construction, and conceptual evaluation.

The first stage classifies the literature into four dimensions: resilience and disruption management; supplier selection and allocation; digital visibility and simulation; and artificial intelligence and machine learning. The second stage identifies relationships among these dimensions. The third stage translates these relationships into SAP-oriented functional components. The fourth stage evaluates the framework against resilience requirements including anticipation, responsiveness, adaptability, visibility, and recovery.

3.2 Conceptual Framework Architecture

The proposed framework consists of six interconnected layers.

Layer 1: Demand and Production Planning. Demand requirements are translated into production plans, production orders, capacity requirements, and material requirements. The planning layer establishes the baseline requirements that procurement must support.

Layer 2: Material and Inventory Synchronization. Material requirements are compared with available inventory, safety stocks, open purchase orders, planned receipts, and consumption requirements. This layer determines the material gap associated with each production requirement.

Layer 3: Procurement and Supplier Capability. Procurement decisions incorporate supplier capacity, lead time, reliability, allocation constraints, and disruption exposure. Hosseini et al. (2019) support the importance of combining supplier selection with order allocation rather than treating supplier choice as an isolated decision.

Layer 4: Resilience Intelligence. AI and machine learning capabilities analyze historical and current information to identify abnormal patterns, supplier risks, demand volatility, and potential material shortages. Belhadi et al. (2022), Cavalcante et al. (2019), Modgil et al. (2022), and Singh and Hannibal (2022) provide the conceptual foundation for this layer.

Layer 5: Scenario and Digital-Twin Analysis. Alternative responses are evaluated through simulation. For example, if a primary supplier becomes unavailable, the framework can examine the consequences of reallocating orders, changing production sequences, increasing inventory buffers, or activating alternative suppliers. This layer reflects the digital supply chain twin perspective of Ivanov et al. (2019).

Layer 6: Execution and Feedback. Approved decisions are translated into production and procurement actions. Actual supplier confirmations, material receipts, production progress, and disruptions are then returned to the planning environment, creating a continuous feedback loop.

3.3 Synchronization Mechanism

The fundamental synchronization relationship can be represented conceptually as:

Production Requirement → Material Requirement → Procurement Requirement → Supplier Capability → Material Availability → Production Feasibility → Revised Production Plan.

Unlike a purely sequential process, the proposed mechanism is iterative. A supplier disruption can move backward through the chain and modify production priorities. Similarly, a change in production demand can move forward and alter procurement requirements.

For example, assume a production order requires 10,000 units of a critical component while available inventory and confirmed receipts cover only 7,000 units. The synchronization layer identifies a 3,000-unit gap. If the preferred supplier cannot provide the shortage within the required lead time, the framework can evaluate alternative suppliers, order redistribution, inventory adjustments, or production rescheduling. Thus, procurement becomes part of production feasibility rather than an independent downstream function.

3.4 Resilience Decision Logic

The framework uses three decision states: normal operation, emerging risk, and disruption response.

During normal operation, SAP planning maintains synchronization between production requirements and procurement commitments. During emerging risk, supplier performance or material availability indicators trigger risk assessment.

During disruption response, scenario analysis evaluates alternative production and sourcing strategies.

The decision logic can be expressed as:

Resilience Response = f(Material Gap, Supplier Risk, Production Criticality, Lead-Time Exposure, Alternative Capacity, Inventory Buffer).

This conceptual function emphasizes that resilience decisions should not depend on a single indicator. A small material shortage may be critical when the component is production-constraining, while a larger shortage may be manageable when substitute materials or alternative suppliers exist.

3.5 Theoretical Foundation

The framework integrates three complementary theoretical perspectives derived from the supplied literature. The first is the resilience perspective, which emphasizes disruption absorption, response, and recovery (Jabbarzadeh et al., 2016; Aldrighetti et al., 2021). The second is the digital visibility perspective, which emphasizes integrated information and end-to-end transparency (Ivanov, 2021; Papadopoulos et al., 2017). The third is the intelligent decision-making perspective, which emphasizes AI, machine learning, simulation, and data-driven optimization (Cavalcante et al., 2019; Belhadi et al., 2022).

Kalal (2026) provides the closest conceptual linkage among SAP production planning, procurement synchronization, and resilience. The present framework extends that linkage by explicitly incorporating supplier resilience, digital visibility, AI-supported risk assessment, and scenario-based decision-making.

3.6 Evaluation Criteria

The conceptual framework is evaluated using five criteria: synchronization, visibility, responsiveness, adaptability, and economic rationality. Synchronization measures whether production and procurement decisions remain aligned. Visibility measures whether decision-makers can observe material and supplier conditions. Responsiveness evaluates the speed of disruption reaction. Adaptability measures the ability to revise plans when conditions change. Economic rationality recognizes the resilience-cost trade-off identified by Aldrighetti et al. (2021).

RESULTS

The synthesis produces five principal findings. First, production-procurement synchronization emerges as a critical operational mechanism for resilience. The literature indicates that supplier disruption, demand interruption, and material uncertainty can propagate through interconnected supply networks (Jabbarzadeh et al., 2016; Hosseini et al., 2019). Consequently, production planning cannot be considered resilient when its material assumptions are disconnected from actual procurement capability. The proposed SAP framework addresses this problem by creating a continuous relationship between production requirements, material gaps, purchasing decisions, supplier capability, and production feasibility. This is consistent with the integrated perspective described by Kalal (2026).

Second, end-to-end visibility represents a necessary condition for effective synchronization. Ivanov (2021) demonstrates the importance of visibility for resilience, while Papadopoulos et al. (2017) highlight the contribution of data in understanding disruption resilience. In the proposed framework, visibility extends beyond inventory levels to include open procurement commitments, supplier conditions, production constraints, and disruption signals. This creates a more complete operational representation of supply availability.

Third, AI and machine learning increase the adaptive potential of synchronization. Cavalcante et al. (2019) demonstrate the applicability of supervised machine learning to resilient supplier-selection simulation, while Belhadi et al. (2022) and Modgil et al. (2022) support AI-based approaches to resilience. The finding is not that AI replaces SAP planning, but that AI can enhance the interpretation of SAP-generated information. This distinction is important because transactional integration and analytical intelligence serve different functions.

Fourth, scenario analysis provides a mechanism for evaluating resilience trade-offs before execution. The digital supply chain twin perspective of Ivanov et al. (2019) suggests that simulation and optimization can be used to analyze ripple effects. Within the proposed architecture, a disruption can therefore be represented as a scenario rather than treated only as an operational exception. The organization can compare alternative sourcing, allocation, inventory, and production responses before selecting an execution strategy.

Fifth, resilience must be balanced against cost. Aldrighetti et al. (2021) indicate that resilience investments involve economic trade-offs. A synchronization framework that automatically maximizes safety stock, supplier redundancy, or expedited procurement could improve responsiveness but undermine cost efficiency. The proposed framework therefore treats resilience as a constrained optimization problem in which service continuity and recovery capability must be balanced against inventory, sourcing, and operational costs.

Overall, the findings indicate that SAP integration becomes strategically valuable when it creates a closed-loop relationship between planning, procurement, risk intelligence, simulation, and execution. The resulting architecture transforms production-procurement synchronization from a transactional interface into a resilience-oriented control mechanism.

DISCUSSION

The findings have significant theoretical implications because they connect traditionally separated perspectives on supply chain resilience. Resilience research emphasizes disruption preparedness and recovery, supplier research emphasizes sourcing and allocation, digital research emphasizes visibility and simulation, and AI research emphasizes intelligent decision support. The proposed framework integrates these perspectives through a common operational mechanism: synchronized production and procurement planning. Kalal (2026) is particularly relevant because the study directly associates integrated SAP production planning–procurement synchronization with supply chain resilience.

From a theoretical perspective, synchronization can be interpreted as the operational bridge between visibility and resilience. Visibility alone does not create resilience if information does not influence decisions. Similarly, AI-based prediction has limited value if predicted supplier risks cannot alter purchasing or production actions. The proposed architecture therefore positions SAP as an execution-oriented integration layer through which analytical insights can influence operational decisions. This extends the implications of Ivanov (2021), whose emphasis on end-to-end visibility indicates that resilience depends on the ability to understand and manage interconnected supply chain conditions.

The framework also clarifies the relationship between supplier resilience and production feasibility. Hosseini et al. (2019) demonstrate the importance of resilient supplier selection and order allocation, while Jabbarzadeh et al. (2016) establish the importance of designing supply chains capable of responding to disruptions. The present framework argues that supplier resilience should be evaluated against production requirements. A supplier may appear reliable at an aggregate level but remain unsuitable for a production-critical component with a narrow delivery window. Consequently, supplier risk should be dynamically evaluated according to production criticality, material requirements, and recovery time.

The role of AI introduces another important trade-off. Belhadi et al. (2022), Modgil et al. (2022), and Singh and Hannibal (2022) establish the relevance of AI for resilience, but AI-driven recommendations require reliable data and appropriate decision rules. A poorly configured intelligent system could propagate inaccurate forecasts or supplier-risk assessments into procurement decisions. Therefore, AI should operate as decision support within controlled planning processes rather than as an unrestricted replacement for managerial judgment.

The framework also has practical implications for manufacturing organizations. A synchronized SAP environment can reduce the delay between recognizing a material constraint and adapting production or procurement. It can also improve coordination between planners and buyers because both functions work from the same operational requirements. However, implementation may require master-data quality, process standardization, organizational coordination, and clearly defined escalation mechanisms.

Several limitations must be recognized. First, the framework is conceptual and has not been empirically validated using real SAP transaction data. Second, the effectiveness of synchronization depends on the accuracy and timeliness of supplier information. Third, resilience objectives may differ across industries, making a universal configuration inappropriate. Fourth, AI and simulation capabilities can introduce additional technological and governance complexity. Finally, the cost-resilience trade-off identified by Aldrighetti et al. (2021) means that greater synchronization does not automatically imply economically optimal resilience.

Future empirical research should test the framework using manufacturing case studies and compare synchronized and non-synchronized planning environments. Performance indicators could include material shortages, production schedule adherence, supplier recovery time, inventory exposure, procurement cycle time, and disruption-related cost. Such research would provide quantitative validation of the conceptual relationship proposed here.

CONCLUSION

This research developed an integrated SAP production planning and procurement synchronization framework for supply chain resilience. The literature synthesis demonstrates that resilient supply chains require more than supplier redundancy or inventory buffers; they require continuous coordination among production requirements, material availability, procurement commitments, supplier capability, disruption information, and recovery decisions.

The proposed framework contributes a six-layer architecture connecting production planning, material and inventory synchronization, supplier procurement, resilience intelligence, scenario analysis, and execution feedback. Its central contribution is the conceptualization of production-procurement synchronization as a resilience mechanism. This perspective is reinforced by the integrated SAP resilience approach of Kalal (2026) and supported by research on resilient supplier selection, disruption management, digital visibility, digital twins, AI, and machine learning.

Practically, the framework provides a basis for organizations seeking to move from reactive disruption management toward continuous, data-driven resilience. Nevertheless, empirical validation remains necessary. Future research should implement the framework in real SAP-enabled manufacturing environments, evaluate its performance under simulated and actual disruptions, and quantify the trade-offs between resilience, inventory, procurement cost, and production continuity.

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