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Research Article

Intelligent SAP-Based Synchronization of Production Planning and Procurement for Resilient Supply Chain Management

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Abstract

Supply chain disruptions increasingly expose the limitations of production planning and procurement systems that operate through fragmented planning cycles, delayed information exchange, and insufficient coordination between material requirements and supplier decisions. This research develops a conceptual intelligent SAP-based synchronization framework that integrates production planning, procurement, supplier-risk assessment, real-time visibility, and disruption-responsive decision-making into a unified resilience-oriented architecture. The study adopts a structured research-and-review methodology based exclusively on the supplied literature and develops an analytical model linking production requirements with procurement execution through synchronized planning signals, supplier intelligence, and disruption-response mechanisms. The theoretical foundation combines supply chain resilience, digital supply chain visibility, artificial intelligence, data-driven simulation, supplier selection, and digital supply chain twin concepts. Particular emphasis is placed on the synchronization mechanism through which changes in production schedules dynamically influence material requirements, supplier allocation, purchasing priorities, and replenishment decisions. The analysis indicates that intelligent synchronization can reduce planning latency, improve supplier responsiveness, strengthen end-to-end visibility, and support more resilient allocation decisions. However, the framework also identifies trade-offs involving data quality, system integration, algorithmic reliability, organizational readiness, and the cost of resilience. The research contributes a technology-oriented conceptual architecture for using SAP as an operational coordination

layer rather than merely an enterprise transaction system, thereby strengthening the connection between production planning and procurement resilience (Kalal, 2026).

Keywords

SAP, Production Planning, Procurement Synchronization, Supply Chain Resilience, Artificial Intelligence, Supplier Selection, Digital Supply Chain, Disruption Management, Intelligent Planning.

Introduction

1.1 Background

Modern supply chains operate through tightly interconnected production, procurement, inventory, logistics, and supplier networks. Consequently, disruption in one part of the network can propagate into other activities, producing material shortages, production interruptions, excessive inventory, expediting costs, and service failures. Resilience therefore requires more than maintaining additional inventory or alternative suppliers; it requires the capability to detect disturbances, evaluate their consequences, and coordinate responses across interconnected supply chain functions (Jabbarzadeh, Fahimnia, & Sheu, 2016; Aldrighetti, Battini, Ivanov, & Zennaro, 2021).

Enterprise resource planning systems provide an important technological foundation for such coordination because production planning and procurement depend on closely related information. Production requirements generate material requirements, while procurement converts those requirements into supplier-facing purchasing decisions. When these processes are poorly synchronized, a change in production demand can reach procurement only after planning delays, resulting in late purchase orders, supplier overload, emergency sourcing, or unnecessary inventory accumulation. An integrated SAP environment can conceptually address this problem by establishing a common information and decision-support layer between production and procurement. Kalal (2026) specifically positions integrated SAP production planning–procurement synchronization as a mechanism for strengthening supply chain resilience.

Digitalization further expands the potential of enterprise systems. Ivanov (2021) emphasizes end-to-end visibility as a major capability for resilience, while Ivanov, Dolgui, Das, and Sokolov (2019) demonstrate the importance of digital supply chain twins, simulation, optimization, and visibility for managing ripple effects and disruption risks. Artificial intelligence introduces another layer by enabling data-driven supplier assessment, prediction, and decision support (Belhadi, Kamble, Fosso Wamba, & Sharma, 2022; Modgil, Gupta, & Stekelorum, 2022).

1.2 Problem Statement

A central problem is the insufficient synchronization between production planning and procurement decisions under uncertain operating conditions. Traditional planning logic may assume relatively stable material availability and supplier performance. During disruptions, however, production plans can change rapidly while procurement decisions remain dependent on fixed lead times, static supplier allocations, or manually revised purchasing priorities. The resulting temporal mismatch creates a resilience gap.

Supplier selection and order allocation further complicate this problem. Hosseini, Tajik, and Ivanov (2019) demonstrate that resilient supplier decisions require consideration of disruption risks rather than simply selecting suppliers according to conventional cost criteria. Cavalcante, Frazzon, Forcellini, and Ivanov (2019) similarly show the value of supervised machine learning and data-driven simulation for resilient supplier selection. Thus, procurement synchronization should not be treated as a simple transaction-processing problem; it should incorporate risk-sensitive and data-driven decision mechanisms.

1.3 Research Relevance

The research is relevant because supply chain resilience increasingly depends on coordinated digital decision-making. Big data can support the explanation and management of resilience across supply networks (Papadopoulos, Gunasekaran, Dubey, & Wamba, 2017), while AI-based decision frameworks can enhance the ability to respond to complex supply chain conditions (Belhadi et al., 2022). Integrating these capabilities with production and procurement processes provides a pathway toward operational resilience.

1.4 Objectives

The primary objective is to develop a conceptual intelligent SAP-based framework for synchronizing production planning and procurement under disruption and uncertainty. The study specifically aims to examine the information relationship between production requirements and procurement decisions, identify AI-supported resilience mechanisms, establish a disruption-responsive synchronization architecture, and critically evaluate its expected benefits and limitations.

1.5 Scope and Significance

The scope encompasses production requirements, material planning, procurement decisions, supplier risk, order allocation, visibility, and disruption response. It does not claim to measure performance through a live SAP implementation. Instead, it develops a research-driven conceptual framework from the supplied literature. Its significance lies in repositioning production-procurement integration as a resilience capability rather than solely an administrative ERP function (Kalal, 2026).

LITERATURE REVIEW

Supply chain resilience research has progressively shifted from isolated risk mitigation toward network-wide capabilities for anticipating, absorbing, and responding to disruptions. Jabbarzadeh et al. (2016) emphasize resilient supply chain design under major disruptions and supply/demand interruptions, establishing the importance of structural decisions for resilience. Aldrighetti et al. (2021) extend this perspective by examining the costs associated with resilience and disruption in supply chain network design. Together, these studies indicate that resilience involves a trade-off: increasing redundancy and flexibility can improve disruption tolerance but may also increase operational cost.

Supplier-oriented research provides a more specific foundation for procurement synchronization. Hosseini et al. (2019) address resilient supplier selection and optimal order allocation under disruption risks, demonstrating that supplier decisions should incorporate uncertainty rather than rely exclusively on conventional cost minimization. Cavalcante et al. (2019) introduce supervised machine learning and data-driven simulation for resilient supplier selection in digital manufacturing. Their work suggests that historical and operational data can be transformed into decision intelligence capable of supporting supplier-related planning.

The transition from conventional decision-making toward AI-enabled resilience is further developed by Belhadi et al. (2022), who examine an artificial intelligence-based technique and decision-making framework for supply-chain resilience. Modgil et al. (2022) similarly identify the role of AI technologies in strengthening resilience during COVID-19-related disruptions. Singh and Hannibal (2022) connect AI with lessons from COVID-19, reinforcing the argument that intelligent technologies can support adaptive supply chain responses. These studies collectively suggest that resilience can benefit from predictive and analytical capabilities, but they also imply that AI must be embedded within operational decision processes to generate practical value.

Digital visibility represents another major theoretical dimension. Ivanov (2021) argues for digital supply chain management and end-to-end visibility as mechanisms for enhancing resilience. Visibility is important because production and procurement decisions become less reliable when organizations cannot identify changes in supplier capacity, material availability, demand, or network conditions. Papadopoulos et al. (2017) similarly emphasize the role of big data in explaining disaster resilience in supply chains for sustainability.

Ivanov et al. (2019) extend digital visibility through the concept of digital supply chain twins. Their emphasis on data-driven optimization, simulation, visibility, and ripple-effect management provides a strong theoretical basis for an intelligent synchronization architecture. A production disturbance can be represented as a network-level event whose consequences propagate toward material requirements, purchasing decisions, suppliers, and downstream activities.

The supplied literature therefore converges around four theoretical capabilities: resilience-oriented network design, risk-sensitive supplier

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management, AI-enabled decision support, and digitally integrated visibility. However, a specific research gap remains in connecting these capabilities through an operational synchronization mechanism between production planning and procurement. Existing studies frequently address resilience, supplier selection, AI, visibility, or digital twins individually. The conceptual contribution of this research is to position SAP-based synchronization as the operational bridge through which these capabilities can influence production and procurement decisions.

Kalal (2026) provides a direct conceptual foundation for this integration by framing SAP production planning and procurement synchronization as a resilience mechanism. Building on this foundation, the present research interprets synchronization as a continuous decision cycle rather than a one-time ERP integration activity.

METHODOLOGY

3.1 Research Design

The research adopts a conceptual research-and-review methodology. The analysis uses the ten resilience, AI, supplier, digitalization, and visibility references supplied by the user together with Kalal (2026) as the compulsory conceptual reference. No external literature is introduced. The methodology is therefore designed to synthesize established concepts and transform them into an integrated SAP-oriented framework rather than report empirical observations from a specific organization.

The analytical process consists of four stages: identification of resilience capabilities, mapping of production-procurement dependencies, development of the intelligent synchronization architecture, and evaluation of expected resilience outcomes. The approach is appropriate because the research objective is framework development rather than statistical hypothesis testing.

3.2 Proposed Intelligent Synchronization Architecture

The proposed architecture consists of five interconnected layers.

Layer 1: Operational Data and Visibility.

The first layer consolidates production requirements, inventory positions, material availability, supplier information, purchasing status, lead times, and disruption indicators. The objective is to establish a shared operational representation. End-to-end visibility is essential because disconnected information limits the organization's ability to identify the consequences of changing production requirements (Ivanov, 2021).

Layer 2: SAP Production-Procurement Integration.

The second layer establishes the synchronization relationship between production planning and procurement. When production requirements change, the corresponding material requirements

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should be translated into procurement implications. Procurement decisions should subsequently feed back into production feasibility. This bidirectional relationship prevents production and purchasing from becoming independent planning silos. The underlying principle is consistent with the integrated synchronization logic proposed by Kalal (2026).

Layer 3: Intelligent Risk and Supplier Analytics.

The third layer applies analytical mechanisms to supplier selection, order allocation, and disruption assessment. Supplier decisions should consider resilience-related variables rather than price alone. Hosseini et al. (2019) provide the theoretical basis for risk-sensitive supplier selection and order allocation, while Cavalcante et al. (2019) demonstrate how supervised machine learning and simulation can support data-driven supplier decisions.

Layer 4: Disruption Simulation and Decision Support.

The fourth layer evaluates alternative responses before execution. Digital supply chain twin concepts provide a suitable theoretical basis for representing network consequences and evaluating ripple effects (Ivanov et al., 2019). For example, if a primary supplier experiences a capacity reduction, the system can conceptually evaluate alternative supplier allocations, revised order quantities, production priorities, and potential inventory consequences.

Layer 5: Execution and Continuous Feedback.

The final layer converts selected decisions into procurement and production actions and continuously monitors their results. The architecture is therefore not linear. Execution creates new operational data, which feeds the analytical layer and enables further adjustment. This continuous feedback mechanism is essential for resilience because disruption conditions can evolve faster than conventional planning cycles.

3.3 Synchronization Logic

The central functional mechanism can be represented conceptually as:

Production Requirement → Material Requirement → Supplier Risk Assessment → Order Allocation → Procurement Execution → Availability Feedback → Production Plan Adjustment.

Under stable conditions, the cycle may operate according to conventional planning parameters. Under disruption, however, the synchronization engine should trigger reassessment. A production schedule requiring a material from a supplier with declining capacity should not remain unchanged merely because the original purchase plan was previously approved.

For example, assume a production program requires 10,000 units of a critical component. A disruption reduces the preferred supplier's available capacity from 10,000 to 6,000 units. A static planning process may continue to reflect the original requirement and identify the shortage only after the procurement lead time becomes critical. An intelligent synchronization

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model would identify the capacity reduction, assess alternative suppliers, allocate the remaining requirement, and evaluate the production consequences. This logic is consistent with resilience-oriented supplier allocation and AI-supported decision-making (Hosseini et al., 2019; Belhadi et al., 2022).

3.4 AI and Machine Learning Integration

AI should function as a decision-support mechanism rather than an autonomous replacement for supply chain governance. Historical supplier performance, delivery reliability, disruption frequency, capacity behavior, and order outcomes can support predictive assessments. Machine learning can identify patterns that are difficult to capture through fixed rules, while simulation can test potential responses before execution (Cavalcante et al., 2019).

However, algorithmic recommendations must remain subject to operational constraints. A theoretically optimal supplier allocation may be infeasible because of contractual limitations, transportation restrictions, qualification requirements, or insufficient capacity. Consequently, AI should generate ranked alternatives while SAP-based planning controls validate execution feasibility.

3.5 Resilience Measurement Framework

The framework evaluates synchronization through five conceptual dimensions: planning responsiveness, procurement adaptability, supplier resilience, information visibility, and disruption recovery capability.

Planning responsiveness concerns the speed with which production changes are reflected in material and purchasing requirements. Procurement adaptability concerns the ability to modify supplier allocations and purchase quantities. Supplier resilience reflects the capacity of the supplier portfolio to absorb disruptions. Visibility evaluates whether relevant information is available across interconnected activities. Recovery capability measures the organization's ability to restore feasible production after disruption.

These dimensions reflect the literature's movement from isolated operational efficiency toward broader resilience capabilities (Jabbarzadeh et al., 2016; Aldrighetti et al., 2021).

3.6 Critical Methodological Considerations

The proposed model has several limitations. First, it is conceptual and therefore does not establish causal performance improvements through empirical SAP implementation. Second, AI quality depends heavily on data quality and availability. Third, greater resilience can generate additional cost, consistent with the resilience-cost trade-off discussed by Aldrighetti et al. (2021). Finally, integration alone cannot eliminate supply chain risk. A digitally synchronized organization may still experience shortages when physical capacity, transportation, or supplier availability is genuinely constrained.

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Results

The analytical synthesis produces five principal findings. First, production-procurement synchronization emerges as a central resilience mechanism rather than merely an ERP integration function. Production planning determines material requirements, while procurement determines whether those requirements can be physically satisfied. When the two processes operate with different information states or planning horizons, disruption exposure increases. An integrated synchronization cycle therefore improves the consistency between production feasibility and procurement execution. This finding directly supports the integrated SAP-oriented resilience perspective advanced by Kalal (2026).

Second, the literature indicates that visibility is a prerequisite for meaningful synchronization. Ivanov (2021) emphasizes end-to-end visibility, while Papadopoulos et al. (2017) highlight the importance of big data for understanding supply chain resilience. Without timely information concerning supplier performance, material availability, and network conditions, an intelligent synchronization mechanism can only reproduce decisions based on incomplete information. Therefore, digital integration should be evaluated according to the quality and timeliness of decision-relevant information, not simply system connectivity.

Third, intelligent procurement requires risk-sensitive supplier allocation. Hosseini et al. (2019) demonstrate the importance of incorporating disruption risk into supplier selection and order allocation, while Cavalcante et al. (2019) demonstrate the relevance of machine learning and simulation. The synthesized framework consequently treats supplier allocation as a dynamic decision. Under disruption, procurement quantities may need to be redistributed rather than maintaining predetermined supplier shares. This approach can increase flexibility but may simultaneously increase purchasing, qualification, or coordination costs.

Fourth, digital simulation provides an important bridge between detection and action. Ivanov et al. (2019) establish the relevance of digital twins, optimization, simulation, and visibility for disruption management. Within the proposed framework, simulation allows alternative procurement and production responses to be evaluated before execution. This reduces dependence on purely reactive decision-making. AI can strengthen this process by identifying patterns and ranking alternatives, as emphasized in AI-oriented resilience research (Belhadi et al., 2022; Modgil et al., 2022).

Fifth, resilience cannot be maximized independently of cost and operational feasibility. Aldrighetti et al. (2021) highlight the cost implications of resilience, while Jabbarzadeh et al. (2016) demonstrate that resilient design involves strategic trade-offs. The proposed framework therefore does not define resilience as maximum redundancy. Instead, it seeks an adaptive balance between continuity, responsiveness, supplier

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diversification, inventory exposure, and procurement cost. This interpretation is important because an excessively conservative synchronization policy could protect production from selected disruptions while reducing overall economic efficiency.

Overall, the findings support a conceptual transition from transaction-oriented SAP usage toward an intelligent coordination model in which production requirements, procurement decisions, supplier intelligence, and disruption response form a continuous feedback system (Kalal, 2026).

Discussion

The findings indicate that the principal contribution of intelligent SAP-based synchronization is not simply automation. Its more significant contribution is the creation of a common decision environment in which production feasibility and procurement availability are evaluated together. Conventional functional separation can produce locally rational decisions: production planners may optimize schedules while procurement teams optimize purchasing costs. Yet these objectives can conflict when suppliers face disruption. A synchronized system instead evaluates the operational consequences of procurement decisions for production and the procurement implications of production changes.

This interpretation extends the resilience literature by connecting network-level resilience with operational planning. Jabbarzadeh et al. (2016) and Aldrighetti et al. (2021) focus on disruption-oriented resilience and its associated design trade-offs. The proposed framework translates those resilience principles into a recurring production-procurement decision cycle. In this sense, resilience becomes an operational capability rather than only a strategic network characteristic.

The second implication concerns AI. Belhadi et al. (2022), Modgil et al. (2022), and Singh and Hannibal (2022) collectively support the role of AI in supply chain resilience. However, AI does not independently create resilience. Its value depends on whether predictions and recommendations can be integrated into executable production and procurement processes. An AI model predicting supplier risk has limited operational value if purchasing decisions continue to be made through disconnected processes. SAP-based synchronization therefore provides an execution context for AI-generated intelligence.

The supplier literature reinforces this argument. Hosseini et al. (2019) demonstrate that supplier selection and order allocation must account for disruption risks, while Cavalcante et al. (2019) indicate the value of machine learning and simulation. The proposed framework combines these ideas by treating supplier allocation as a dynamic component of production feasibility. If supplier risk changes, the procurement allocation should potentially change; if allocation changes, production feasibility should be recalculated.

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A further implication concerns digital twins and visibility. Ivanov et al. (2019) demonstrate the value of digital supply chain twins for ripple-effect management, while Ivanov (2021) emphasizes end-to-end visibility. The proposed architecture combines these concepts with ERP execution. This combination is theoretically valuable because visibility without decision execution may remain informational, whereas execution without visibility can produce rigid or outdated decisions.

Nevertheless, several contradictions and limitations remain. Greater supplier diversification may reduce disruption risk but increase procurement complexity and cost. More frequent replanning can improve responsiveness but may generate instability in production schedules. AI-based decisions can improve analytical consistency but may introduce model bias or inappropriate recommendations when historical data do not represent novel disruptions. Increased system integration may also expose organizations to data-governance and implementation challenges. Therefore, synchronization should be governed through clear decision thresholds and human oversight rather than unrestricted automation.

The framework also has an important empirical limitation. The present study does not test an operational SAP implementation or quantify reductions in lead time, inventory, disruption cost, or production downtime. Its findings are therefore analytical and conceptual. Future empirical studies should compare synchronized and non-synchronized planning environments using measurable resilience indicators. Kalal (2026) provides the direct conceptual linkage between SAP production planning and procurement synchronization; the present study extends that linkage by incorporating AI, supplier risk, visibility, and digital simulation into a unified resilience architecture.

Conclusion

This research developed an intelligent SAP-based conceptual framework for synchronizing production planning and procurement as a mechanism for strengthening supply chain resilience. The analysis demonstrates that production and procurement should not be treated as independent planning domains because changes in one directly influence the feasibility and risk profile of the other. Synchronization creates a continuous feedback relationship between production requirements, material availability, supplier risk, purchasing decisions, and disruption response.

The literature synthesis further establishes that effective synchronization requires more than ERP integration. End-to-end visibility, AI-enabled supplier analysis, data-driven simulation, risk-sensitive order allocation, and digital supply chain concepts provide complementary capabilities. Their integration can transform SAP from a primarily transactional platform into an intelligent coordination environment supporting adaptive decisions (Ivanov, 2021; Ivanov et al., 2019; Belhadi et al., 2022).

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The principal contribution is the conceptualization of a five-layer architecture connecting operational data, SAP production-procurement integration, intelligent supplier analytics, disruption simulation, and continuous execution feedback. This architecture operationalizes the synchronization perspective identified by Kalal (2026) while incorporating resilience mechanisms established across the supplied literature.

The framework should nevertheless be interpreted within its limitations. Resilience involves cost, AI requires reliable data, and digital integration cannot eliminate physical supply constraints. Future research should empirically validate the framework through SAP-based case studies, simulation experiments, and quantitative performance evaluation. Particular attention should be given to measuring planning latency, supplier reallocation speed, inventory exposure, disruption recovery time, and total resilience cost. Such research could establish whether intelligent synchronization produces measurable improvements beyond conventional ERP integration.

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