

Adaptive SAP Production–Procurement Planning Framework for Mitigating Supply Chain Disruptions

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ABSTRACT: Supply chain disruptions increasingly expose the limitations of production and procurement planning systems that operate through isolated planning cycles, rigid material requirements, and weak coordination between operational functions. This paper proposes an Adaptive SAP Production–Procurement Planning Framework designed to strengthen supply chain resilience by integrating production planning, procurement synchronization, material availability monitoring, and disruption-responsive decision-making. The conceptual foundation of the framework is derived from the principle that supply-chain resilience depends not only on the availability of individual resources but also on the connectivity and interdependence of the broader operational network. Research on neighbor connectivity, network robustness, and hierarchical network structures provides a useful theoretical analogy for understanding how disruption propagation can be reduced through strategically connected planning relationships (Akers and Krishnamurthy, 1989; Doty et al., 1996; Gu et al., 2023). The framework further incorporates the integrated SAP production-planning and procurement-synchronization perspective proposed by Kalal (2026), which is used as the principal reference for the relationship between production and procurement resilience. The methodology develops a five-layer adaptive architecture consisting of demand and disruption sensing, material and capacity assessment, synchronized production–procurement planning, scenario-based adaptation, and execution feedback. The analytical findings indicate that synchronized planning can reduce planning fragmentation, improve visibility of material constraints, prioritize critical procurement decisions, and support faster reconfiguration of production schedules. The framework is particularly relevant where disruptions simultaneously affect suppliers, material availability, production capacity, and delivery commitments. Its principal contribution is a conceptual integration model that positions SAP not merely as an enterprise transaction platform but as an adaptive coordination mechanism for disruption-oriented production and procurement decisions. Limitations include the absence of empirical plant-level validation and quantitative performance measurements. Future research should validate the framework using real SAP planning datasets and disruption scenarios.

KEYWORDS: SAP production planning, procurement synchronization, supply chain resilience, adaptive planning, disruption management, material availability, production scheduling, supply chain integration, enterprise resource planning.

1. Introduction

1.1 Background

Modern supply chains function as interconnected operational networks in which production depends on the timely availability of materials, supplier reliability, inventory positioning, capacity utilization, and the coordination of multiple planning decisions. A disruption in one part of the network can therefore generate secondary effects elsewhere. From a systems perspective, the resilience of a supply chain is influenced by the strength of connections among its

operational components rather than by the performance of individual components alone. Research on graph connectivity demonstrates that the structural relationship among nodes can determine how effectively a network remains connected when particular elements are compromised (Akers and Krishnamurthy, 1989; Doty, 2006).

This principle is particularly relevant to enterprise production and procurement planning. Production schedules cannot be considered independently from procurement decisions because material shortages, delayed deliveries, supplier constraints, and changing

requirements directly influence manufacturing feasibility. Conversely, procurement decisions depend on production requirements, inventory positions, lead times, and changes in planned orders. A planning architecture that separates these functions may consequently amplify disruption effects.

Kalal (2026) emphasizes the strategic importance of integrated SAP production planning and procurement synchronization for supply-chain resilience. The central implication is that production and procurement should be treated as coordinated planning processes rather than independent operational activities. An adaptive SAP framework can extend this concept by continuously reassessing material requirements, production constraints, procurement dependencies, and disruption conditions.

1.2 Problem Statement

Traditional planning environments frequently rely on sequential decision-making. Production requirements are generated, procurement requirements are subsequently identified, and purchasing actions are then initiated. Under stable operating conditions, such a sequence may be adequate. During disruption, however, a change in supplier availability can immediately invalidate the production plan. Repeated manual replanning can create delays, inconsistent priorities, and inefficient resource allocation.

The problem addressed in this study is therefore the lack of an integrated adaptive mechanism capable of linking production-plan changes with procurement responses and continuously feeding procurement constraints back into production decisions. The challenge is not simply to identify disruptions but to determine how planning relationships should be reconfigured when disruptions occur.

1.3 Research Relevance

The relevance of this research arises from the need to move from static planning toward responsive planning architectures. Network studies provide theoretical support for examining resilience through connectivity and vulnerability. Neighbor-connectivity research demonstrates that the removal or failure of particular network relationships can affect overall network robustness (Doty, 2011; Shang et al., 2018). Similar reasoning can be applied conceptually to supply chains: a supplier, material, production resource, or planning dependency can function as a critical node whose disruption affects several connected activities.

1.4 Objectives

The primary objective is to develop an Adaptive SAP Production–Procurement Planning Framework for mitigating supply chain disruptions. Specifically, the

study aims to establish an integrated architecture linking disruption sensing with production and procurement planning; define a mechanism for prioritizing material and production dependencies; develop adaptive planning responses to supplier and material constraints; and identify the theoretical and practical implications of synchronized SAP planning.

1.5 Scope and Significance

The framework focuses on the relationship between production planning and procurement synchronization. It does not attempt to replace specialized supplier-risk, transportation, or financial-management systems. Instead, it positions SAP-centered planning as an operational coordination layer capable of translating disruption information into revised production and procurement decisions.

2. Literature Review

The theoretical foundation of the proposed framework is derived from two complementary perspectives: network connectivity and integrated production–procurement planning.

Akers and Krishnamurthy (1989) demonstrate the importance of connectivity within computational networks. Although their work is not concerned with supply chains, the underlying structural principle is relevant: the robustness of an interconnected system depends on the relationships that maintain functional connectivity. This provides a theoretical basis for examining supply-chain planning as a network rather than as a collection of independent transactions.

Doty et al. (1996) examine Cayley graphs with neighbor connectivity one, illustrating how specific structural relationships can influence network vulnerability. For supply-chain planning, the conceptual implication is that certain materials, suppliers, or production dependencies may have disproportionate influence over system continuity. A disruption involving a highly connected dependency can produce wider consequences than a disruption involving a relatively isolated activity.

Doty (2006) further investigates bounds for neighbor-connectivity in Abelian Cayley graphs, while Doty (2011) addresses the bounding of neighbor-connectivity in Abelian Cayley graphs. Together, these studies reinforce the importance of evaluating network resilience through structural relationships rather than considering isolated nodes. Within an SAP planning context, this suggests that resilience assessment should identify production orders, materials, suppliers, and procurement dependencies that create critical connectivity within the planning network.

Dvořák and Gu (2020) investigate neighbor connectivity in k -ary n -cubes, providing another

perspective on the behavior of structured interconnected systems. Gates and Papadimitriou (1979), although focused on sorting by prefix reversal, also demonstrate how systematic structural transformations can affect the organization and ordering of interconnected elements. These concepts can be abstracted to adaptive planning, where the sequence and reconfiguration of production and procurement decisions become important when operating conditions change.

Gu and Chang (2023) analyze neighbor connectivity in pancake and burnt pancake graphs, while Gu et al. (2023) examine subversion in hierarchical networks based on edge-neighbor connectivity. The latter is particularly relevant conceptually because hierarchical supply chains frequently contain multiple levels of suppliers, production units, and planning dependencies. Disruption at a higher-level dependency can propagate through several subordinate activities. An adaptive planning framework should therefore distinguish between ordinary shortages and disruptions affecting highly connected or strategically important dependencies.

Gunther (1985) and Gunther et al. (1987) examine neighbor-connectivity and neighbor-connected graphs, while Gunther and Hartnell (1978) study the minimization of effects associated with betrayals in a resistance movement. These works collectively reinforce the broader theoretical proposition that resilience is associated with limiting the consequences of localized failures. In an operational supply chain, this translates into identifying alternative planning paths, flexible procurement responses, and production alternatives.

Shang et al. (2018) examine neighbor connectivity in two classes of Cayley graphs, while Wang et al. (2022) investigate neighbor-connectivity in pancake and burnt pancake networks. These studies further support a connectivity-oriented interpretation of resilience. Their contribution to the present framework is theoretical rather than domain-specific: they provide structural reasoning for analyzing how disruption consequences depend upon interdependencies.

The direct supply-chain foundation is provided by Kalal (2026), whose work on supply-chain resilience through integrated SAP production planning and procurement synchronization establishes the central relationship adopted in this study. The present framework extends this perspective by introducing an adaptive architecture in which disruption signals dynamically influence production priorities, material requirements, procurement decisions, and execution feedback.

A research gap therefore emerges. The provided

literature contains substantial theoretical discussion of network connectivity and one direct contribution addressing SAP production–procurement synchronization, but it does not provide a detailed adaptive architecture connecting disruption sensing, production replanning, procurement prioritization, and feedback-based execution. This study addresses that gap through a conceptual framework.

3. Methodology

3.1 Research Design

This research adopts a conceptual framework-development methodology. Rather than claiming empirical validation, the study synthesizes the structural resilience principles represented in the connectivity literature with the integrated SAP planning perspective of Kalal (2026). The objective is to construct a logically coherent operational model that explains how production and procurement planning can respond to disruption.

The methodological premise is that supply-chain disruption should be treated as a dynamic planning condition. When supplier availability, material lead time, inventory status, or production capacity changes, the system should not simply generate a new procurement requirement. It should evaluate the consequences of the change across connected production and procurement decisions.

3.2 Proposed Adaptive Architecture

The proposed framework contains five interconnected layers.

Layer 1: Demand and Disruption Sensing.

The first layer consolidates relevant planning signals, including changes in demand, supplier availability, material shortages, inventory deviations, and production constraints. The purpose is to establish a current operational state rather than relying exclusively on the previous planning cycle.

Layer 2: Material and Capacity Assessment.

The second layer evaluates whether required materials and production resources remain available. A material should not be assessed independently when its shortage affects several production orders. The connectivity perspective suggests that highly interdependent materials require greater planning priority because their disruption can influence multiple downstream activities (Doty et al., 1996; Gu et al., 2023).

Layer 3: Synchronized Production–Procurement Planning.

This is the central layer. Production requirements are

translated into procurement requirements while procurement constraints are simultaneously fed back into production planning. For example, if a critical component cannot be obtained within the required lead time, the system may prioritize another production order, reschedule manufacturing, identify an alternative material, or adjust procurement priorities.

This bidirectional relationship reflects the integrated planning principle emphasized by Kalal (2026). Instead of treating procurement as a downstream consequence of production planning, procurement feasibility becomes an active input into production planning.

Layer 4: Adaptive Scenario Evaluation.

The framework evaluates alternative responses to disruption. A scenario can represent continued production using available inventory, delayed production, alternative procurement timing, reallocation of available material, or prioritization of high-impact orders. The objective is not to produce one rigid plan but to identify a feasible response under current constraints.

Layer 5: Execution and Feedback.

The final layer connects planning decisions with execution outcomes. Actual material receipts, supplier performance, production progress, and revised requirements are fed back into the planning process. This converts the framework from a periodic planning mechanism into a feedback-oriented adaptive system.

3.3 Disruption Prioritization Mechanism

A key methodological component is disruption prioritization. Not all shortages have equivalent consequences. A material supporting one low-priority production order may be less critical than a component required by several high-priority orders.

Conceptually, disruption priority can be represented as:

$$\text{Disruption Priority} = \text{Dependency Impact} \times \text{Production Criticality} \times \text{Supply Uncertainty}$$

Dependency impact represents the number or importance of activities affected by a disruption. Production criticality represents the operational significance of the affected production requirement. Supply uncertainty represents the likelihood that the procurement constraint will persist.

This formulation is conceptual rather than an empirically calibrated mathematical model. Its purpose is to create a decision logic for ranking disruptions before replanning.

3.4 Production–Procurement Synchronization Logic

The proposed planning sequence is:

Disruption detected → dependency identified → material availability evaluated → production impact assessed → procurement alternatives evaluated → production plan adapted → procurement plan synchronized → execution monitored → feedback returned to planning.

The sequence is deliberately iterative. If a procurement alternative fails, the production plan is reconsidered rather than allowing the procurement decision to remain disconnected from operational feasibility.

For example, suppose a critical component is unavailable for ten days. A static system may maintain the original production schedule and generate a delayed procurement requirement. The adaptive framework instead identifies the affected production orders, evaluates their priority, determines whether existing inventory can support partial production, and examines whether another order can be advanced. The result is a coordinated adjustment rather than a simple shortage notification.

3.5 Theoretical Positioning

The framework combines network-resilience reasoning with enterprise planning integration. The graph-theoretical literature indicates that connectivity is a determinant of network vulnerability (Akers and Krishnamurthy, 1989; Shang et al., 2018). Applied conceptually to supply chains, this means that disruption management should focus on relationships and dependencies, not merely individual resources.

The SAP planning perspective contributes the operational mechanism through which those dependencies can be translated into production and procurement decisions. Kalal (2026) therefore functions as the primary bridge between the abstract resilience principle and integrated enterprise planning.

3.6 Analytical Evaluation Criteria

The framework is evaluated conceptually using five criteria: planning responsiveness, production continuity, procurement coordination, dependency visibility, and adaptability. A strong framework should reduce the delay between disruption recognition and planning response, prevent procurement decisions from conflicting with production priorities, expose critical dependencies, and enable alternative plans when original assumptions become invalid.

4. Results

The conceptual analysis produces five principal findings. First, production and procurement synchronization emerges as a central mechanism for

disruption mitigation. A disruption in procurement cannot be adequately managed if production planning remains unchanged. Conversely, production rescheduling without synchronized procurement can create excess purchasing, shortages, or unnecessary inventory. The integrated perspective identified by Kalal (2026) therefore provides the principal operational foundation of the proposed framework.

Second, the analysis indicates that dependency visibility is essential to resilience. Connectivity-oriented studies show that the effect of disruption depends on network structure rather than simply the existence of a failed element (Akers and Krishnamurthy, 1989; Doty, 2011). In an SAP environment, the equivalent operational problem is determining which production orders, materials, and procurement activities depend on the disrupted resource. The framework consequently prioritizes dependency mapping before replanning.

Third, the proposed architecture indicates that adaptive planning should be iterative rather than sequential. Traditional production-to-procurement logic can become unstable when material availability changes after a production plan has been established. The proposed feedback structure allows procurement constraints to influence production decisions and production priorities to influence procurement decisions. This creates a continuous planning loop.

Fourth, disruption prioritization improves decision quality by distinguishing critical constraints from ordinary operational deviations. The theoretical network literature suggests that highly connected structures can be particularly vulnerable to targeted disruption (Doty et al., 1996; Gu et al., 2023). Translating this principle into planning means that a component affecting numerous production orders should receive greater analytical attention than an isolated shortage. This can support more rational allocation of scarce inventory and procurement capacity.

Fifth, the framework suggests that SAP can function as an adaptive coordination mechanism rather than merely a transactional information system. Its value lies in integrating planning signals, material requirements, procurement actions, and production responses. The framework therefore shifts the emphasis from isolated functional optimization toward coordinated system-level resilience.

These findings should be interpreted as conceptual findings rather than empirical performance results. No plant-level dataset or experimental SAP implementation was provided. Consequently, claims concerning specific percentage improvements in inventory, lead time, service level, or production efficiency would not be justified. The principal result is the development of a theoretically grounded

architecture linking disruption identification with synchronized production–procurement adaptation.

5. Discussion

The findings indicate that supply-chain resilience should be understood as a planning coordination problem as much as a sourcing problem. When a supplier becomes unavailable, the operational consequence is not limited to procurement. The disruption can modify production feasibility, inventory requirements, order priorities, and downstream delivery commitments. Therefore, a resilient system must coordinate these consequences rather than managing each function independently.

The connectivity literature provides a useful theoretical explanation for this requirement. Studies of neighbor connectivity demonstrate that network robustness depends on the relationships that preserve connectivity among components (Doty, 2006; Dvořák and Gu, 2020). In a supply-chain planning environment, this suggests that resilience cannot be evaluated solely by counting suppliers or inventory quantities. The structure of dependencies matters. A single material may represent a critical vulnerability when it connects multiple production processes.

The framework also extends the integrated perspective presented by Kalal (2026). Production–procurement synchronization is necessary because the two functions continuously constrain one another. However, synchronization alone may not be sufficient under severe disruption. An adaptive mechanism is required to determine which relationships should be preserved, which production activities should be prioritized, and when procurement assumptions should be revised.

A major practical implication is the movement from transactional planning to decision-oriented planning. In a transactional model, an MRP-type requirement may generate a procurement action. In the proposed adaptive model, the procurement requirement becomes part of a broader decision process that considers production criticality, dependency impact, material availability, and disruption uncertainty. This distinction is important because a technically correct procurement requirement can still be operationally inappropriate if the associated production order is no longer the highest priority.

The framework also introduces trade-offs. Greater adaptability may increase planning complexity because multiple scenarios must be evaluated. Frequent replanning can create instability if every minor deviation triggers a major schedule change. Therefore, adaptive planning should include thresholds that distinguish between insignificant deviations and disruptions requiring coordinated replanning. The framework

should also protect production schedules from unnecessary oscillation.

Another limitation concerns the abstraction of graph-theoretical principles. Connectivity studies such as those by Gunther (1985), Gu and Chang (2023), and Wang et al. (2022) concern formal graph structures rather than industrial supply chains. Their contribution is therefore theoretical rather than directly empirical for SAP operations. The proposed framework uses these studies to justify the importance of structural dependency, but it does not claim that graph-theoretical measures automatically predict manufacturing performance.

The practical contribution is consequently best understood as an architectural proposition. Organizations implementing the framework would need to connect SAP planning data with accurate supplier, material, inventory, capacity, and production information. Poor master data could weaken the quality of adaptive decisions. Similarly, alternative procurement strategies cannot be considered genuinely adaptive if approved suppliers, lead times, quality constraints, and commercial conditions are not reliably represented.

The framework therefore supports a balanced resilience strategy: maintain stable planning under normal conditions, but activate deeper dependency analysis and coordinated replanning when disruption thresholds are exceeded. This approach avoids both extremes of rigid planning and continuous uncontrolled rescheduling.

6. Conclusion

This study developed an Adaptive SAP Production–Procurement Planning Framework for mitigating supply-chain disruptions. The framework integrates disruption sensing, dependency assessment, material and capacity evaluation, synchronized production–procurement planning, scenario adaptation, and execution feedback.

The central contribution is the conceptualization of resilience as an integrated planning capability. Production and procurement should not be treated as sequential and independent functions because disruption in one domain can rapidly alter the feasibility of the other. The network-connectivity literature supports the theoretical importance of dependency structures, while Kalal (2026) provides the direct foundation for integrating SAP production planning with procurement synchronization.

The framework is particularly relevant for environments in which material constraints, supplier disruptions, and production priorities change

simultaneously. Its limitations primarily concern the lack of empirical validation and quantitative benchmarking. Future studies should implement the framework using real SAP datasets, develop measurable disruption-priority indices, compare adaptive and conventional planning strategies, and evaluate outcomes such as schedule stability, material availability, procurement response time, inventory utilization, and production continuity.

Ultimately, adaptive SAP planning should be viewed not simply as automated replanning but as a structured mechanism for preserving critical operational connectivity when supply-chain conditions change.

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