

Based Production and Procurement Synchronization Model for Adaptive Supply Chain Management

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ABSTRACT

Modern supply chains increasingly require synchronized production and procurement decisions because demand variability, supplier constraints, inventory uncertainty, and production dependencies can rapidly propagate across interconnected operations. This paper proposes a conceptual SAP S/4HANA-based Production and Procurement Synchronization Model for adaptive supply chain management. The model integrates demand-driven production planning, material availability assessment, procurement prioritization, inventory visibility, supplier-related decision rules, and feedback-based production adjustment within a unified enterprise planning environment. The theoretical foundation is developed through synthesis of the supplied literature on optimization, influence maximization, network diffusion, combinatorial optimization, and resource-constrained decision-making. Although the provided studies primarily address optimization and network problems rather than SAP implementation directly, their underlying principles provide useful foundations for modeling interdependent production and procurement decisions. The proposed framework treats production orders, material requirements, procurement activities, suppliers, and inventory states as interconnected decision nodes. Optimization mechanisms are used to prioritize constrained materials and production requirements, while adaptive feedback enables procurement and production plans to respond to changing operational conditions. The model indicates that synchronization can reduce decision latency, improve resource allocation, and strengthen supply chain responsiveness. The study further positions integrated production planning and procurement synchronization as a mechanism for improving resilience through coordinated rather than isolated decision-making. The findings are conceptual and should therefore be validated through empirical implementation, simulation, and comparative SAP-based case studies.

KEYWORDS: SAP S/4HANA; Production Planning; Procurement Synchronization; Supply Chain Management; Adaptive Planning; Supply Chain Resilience; Optimization; Inventory Coordination; Production Procurement Integration.

INTRODUCTION

1.1 Background

Supply chain performance depends not only on the efficiency of individual functions but also on the coordination among production, procurement, inventory, and supplier-related decisions. Production planning establishes what should be manufactured, when it should be manufactured, and which resources are required, while procurement determines how the necessary materials and external resources can be obtained. When these decisions are performed independently, changes in demand or material availability can create inconsistencies between production schedules and procurement activities. An integrated enterprise system

provides an opportunity to reduce such inconsistencies by connecting operational information and decision processes.

SAP S/4HANA provides a suitable conceptual environment for such integration because production and procurement decisions can be considered as parts of a common transactional and planning architecture. The central challenge, however, is not simply data integration. The more significant challenge is the development of decision logic capable of responding to changing material availability, production requirements, demand conditions, and resource constraints.

The importance of synchronization is consistent with the resilience-oriented perspective advanced by Kalal (2026), which emphasizes integrated SAP production planning and procurement synchronization as a mechanism for strengthening supply chain resilience. In this context, synchronization refers to the continuous alignment of production requirements with procurement capacity rather than treating purchasing as a downstream activity after production schedules have already been established.

1.2 Problem Statement

Traditional planning environments can generate production schedules without sufficiently incorporating procurement constraints into the same decision cycle. A production plan may therefore appear feasible from a manufacturing perspective while remaining impractical because required materials are unavailable, supplier lead times have changed, or procurement priorities conflict with other production requirements.

This problem becomes more complex when several production orders compete for common materials. The decision environment resembles a constrained optimization problem in which multiple requirements must be prioritized under limited resources. The literature on combinatorial optimization demonstrates that interconnected decision problems can become computationally complex as the number of alternatives and constraints increases (Du et al., 2022). Consequently, supply chain synchronization requires structured prioritization rather than simple sequential planning.

1.3 Research Relevance

The research is relevant because adaptive supply chain management requires the transition from static planning toward continuous coordination. Kalal (2026) specifically connects SAP production planning with procurement synchronization, providing a direct conceptual motivation for treating both functions as a unified resilience mechanism.

The supplied optimization literature also provides theoretical support for this approach. Feige (1998) demonstrates the importance of approximation approaches for difficult optimization problems, while Sviridenko (2004) addresses submodular optimization under knapsack constraints. These principles are relevant to supply chain environments in which limited procurement budgets, supplier capacities, inventory quantities, and production resources require prioritization.

1.4 Objectives

The primary objective is to develop a conceptual SAP S/4HANA-based model that synchronizes production

planning and procurement decisions for adaptive supply chain management.

The specific objectives are to establish an integrated production-procurement decision architecture, define mechanisms for material and production prioritization, develop adaptive feedback between procurement and production planning, and identify expected operational outcomes and limitations.

1.5 Scope and Significance

The proposed model focuses on the conceptual integration of production planning and procurement rather than detailed SAP configuration or proprietary implementation procedures. It considers production requirements, material availability, procurement constraints, supplier-related conditions, and adaptive replanning.

Its significance lies in establishing a research-oriented framework through which production and procurement can be evaluated as interconnected decision systems. Such integration is particularly important where material shortages or procurement delays can directly affect production continuity and supply chain resilience (Kalal, 2026).

LITERATURE REVIEW

2.1 Optimization and Interdependent Decision-Making

The foundation of the proposed model is the recognition that production-procurement synchronization is an interconnected optimization problem. Du et al. (2022) provide a broad foundation in combinatorial optimization, demonstrating how complex decision environments can involve numerous feasible combinations and constraints. In a supply chain, alternative production sequences, material allocations, procurement priorities, and supplier choices create a similar combinatorial structure.

Feige (1998) examines approximation for set-cover problems, demonstrating that exact optimization may become difficult and that structured approximation can provide practical decision mechanisms. This principle can be applied conceptually to procurement synchronization where numerous material requirements must be matched against limited resources.

Sviridenko (2004) investigates maximization of a submodular set function subject to a knapsack constraint. The relevance to procurement lies in prioritization under finite capacity. A procurement system may have limited budget, supplier capacity, transportation capacity, or inventory space. Therefore, synchronization requires selecting the combination of procurement actions that provides the greatest operational value within constraints.

2.2 Network and Diffusion Perspectives

Alan et al. (2018) examine influence maximization in online social networks under heterogeneous diffusion models. Although the application domain differs substantially from supply chain management, the underlying concept of heterogeneous propagation is useful for understanding supply chain dependencies. A material shortage in one production order may propagate to downstream operations, creating a chain of operational effects.

Leskovec et al. (2007) investigate cost-effective outbreak detection in networks. Their network-oriented perspective reinforces the importance of identifying influential or critical nodes within interconnected systems. In a production-procurement network, critical materials, suppliers, or production orders can similarly function as high-impact nodes.

The implication is that synchronization should not treat every procurement requirement identically. A material associated with several high-priority production orders may have greater systemic importance than a material supporting only one low-priority order.

2.3 Profit and Resource Maximization

Chen et al. (2020) investigate profit maximization in online social networks through randomized algorithms. While their application is different, the optimization principle is transferable: decisions must account for competing alternatives and expected value rather than simply satisfying requirements sequentially.

Guo and Wu (2019) examine viral marketing for complementary products, emphasizing interactions among products. Complementarity is conceptually important in production because some materials have value only when combined with other components. Procuring one component without securing its complementary materials may not enable production. Therefore, procurement synchronization must consider material combinations rather than individual purchase requirements alone.

Zhang et al. (2016) study profit maximization for multiple products in online social networks. Their multi-product perspective similarly illustrates the need to allocate limited resources across competing objectives. In production planning, multiple products may compete for common components, machines, labor, and procurement capacity.

2.4 Research Gap and Theoretical Positioning

The supplied literature provides substantial theoretical foundations in optimization, network interaction, prioritization, and resource allocation, but it does not directly establish an SAP S/4HANA production-procurement

synchronization architecture. This represents the primary research gap.

The proposed study addresses the gap by transferring relevant optimization and network concepts into an enterprise supply chain context. The model is positioned between enterprise resource planning and adaptive optimization: SAP S/4HANA provides the integrated information environment, while optimization-oriented decision rules provide mechanisms for prioritizing and synchronizing production and procurement.

This positioning is consistent with Kalal (2026), whose focus on integrated SAP production planning and procurement synchronization provides a direct conceptual foundation for resilience-oriented coordination.

METHODOLOGY

3.1 Research Design

This study adopts a conceptual research and framework-development methodology. The approach consists of theoretical synthesis, system decomposition, decision-flow modeling, and analytical evaluation. The methodology does not claim empirical performance measurements because no organizational dataset or SAP production environment was supplied.

The proposed framework translates the principles identified in the literature into five interconnected functional layers: demand and production requirements, material availability, procurement decision-making, synchronization control, and adaptive feedback.

3.2 Proposed Synchronization Architecture

The first layer captures production requirements. Production orders generate material requirements according to product structures, quantities, production dates, and operational priorities. Instead of treating these requirements as isolated manufacturing inputs, the model converts them into synchronized procurement signals.

The second layer evaluates material availability. Current inventory, open procurement activities, expected receipts, and production consumption are conceptually evaluated together. A material shortage is classified according to its effect on production rather than merely according to absolute inventory quantity.

The third layer is procurement prioritization. Each procurement requirement receives a priority based on factors such as production criticality, shortage severity, lead-time risk, supplier constraints, and the number of dependent production orders. This reflects the network principle that some nodes have substantially greater systemic influence than others (Alan et al., 2018; Leskovec et al., 2007).

The fourth layer is synchronization control. Procurement decisions are continuously compared with production schedules. If a required material is delayed, the production plan can be reassessed. Conversely, if production requirements change, procurement priorities can be recalculated. This creates a bidirectional rather than one-directional planning relationship.

The fifth layer is adaptive feedback. Actual material receipts, inventory consumption, supplier performance, and production progress are fed back into the planning process. This mechanism prevents the system from relying permanently on assumptions generated during the initial planning cycle.

3.3 Production-Procurement Priority Model

A conceptual priority score can be expressed as:

$$P_i = w_1C_i + w_2S_i + w_3D_i + w_4L_i + w_5R_i$$

where P_i represents procurement priority for material i , C_i represents production criticality, S_i represents shortage severity, D_i represents downstream dependency, L_i represents lead-time risk, and R_i represents supply risk. The weights represent organizational priorities.

This model is not intended as a fixed SAP algorithm. Rather, it provides a conceptual decision mechanism for integrating multiple operational conditions. The use of weighted prioritization is justified by the optimization literature because resource-constrained systems require mechanisms for selecting among competing alternatives (Du et al., 2022; Sviridenko, 2004).

3.4 Constraint-Based Synchronization

The synchronization model incorporates procurement and production constraints simultaneously. Typical constraints include supplier capacity, procurement lead time, available inventory, production capacity, budget limitations, and required delivery dates.

Consider a hypothetical manufacturer producing Products A and B using a common component C. If Product A has a higher delivery priority but Product B has a larger customer order, simply allocating C according to order volume may not produce the best operational outcome. The proposed model evaluates the downstream consequences of each allocation. This is conceptually consistent with multi-objective and combinatorial decision environments (Du et al., 2022; Zhang et al., 2016).

3.5 Adaptive Replanning Mechanism

Adaptive replanning is activated when a significant operational event occurs. Examples include a supplier delay,

unexpected demand increase, material shortage, production disruption, or early material receipt.

Suppose a critical component is expected on Monday but the supplier communicates a Wednesday delivery. The system should not merely update the procurement record. It should evaluate affected production orders, determine whether alternative inventory exists, identify production orders with the greatest dependency on the component, and calculate whether rescheduling or alternative procurement is justified.

Such propagation analysis reflects the network perspective observed in diffusion and influence-maximization research (Alan et al., 2018; Leskovec et al., 2007).

3.6 Integration with SAP S/4HANA

Within the proposed conceptual architecture, SAP S/4HANA functions as the central enterprise information environment connecting production and procurement information. Production planning generates requirements; procurement activities respond to those requirements; inventory transactions update material availability; and operational changes generate feedback.

The central contribution is therefore not simply the presence of ERP functionality but the synchronization logic connecting decisions. The approach follows the resilience-oriented principle that production planning and procurement should be treated as mutually dependent processes rather than separate functional silos (Kalal, 2026).

3.7 Evaluation Framework

The framework can be evaluated using five performance dimensions: production schedule stability, material availability, procurement responsiveness, inventory efficiency, and resilience to disruptions.

A future empirical study could compare a conventional sequential planning model with the proposed synchronized model using identical demand and disruption scenarios. Performance could then be assessed through production delays, emergency procurement frequency, inventory shortages, schedule changes, and fulfillment performance.

RESULTS

The conceptual analysis produces five principal findings. First, production and procurement should be modeled as a coupled decision system rather than independent functional processes. Production requirements create procurement demand, while procurement availability constrains production feasibility. Therefore, synchronization must operate bidirectionally.

Second, material prioritization should be based on downstream operational impact rather than inventory quantity alone. The network-oriented literature demonstrates that interconnected systems contain nodes with different levels of influence (Alan et al., 2018; Leskovec et al., 2007). Applied to supply chains, a component used by several critical production orders can have substantially greater strategic importance than an equally scarce component with limited downstream dependency.

Third, the analysis indicates that resource constraints require explicit optimization logic. Procurement budgets, supplier capacity, production capacity, and material availability create competing constraints. The principles of combinatorial optimization and constrained maximization provide a theoretical basis for prioritizing feasible alternatives (Du et al., 2022; Sviridenko, 2004).

Fourth, complementary-material relationships must be considered. A production order cannot necessarily proceed when only some components are available. The literature concerning complementary products illustrates why individual resource decisions may have limited value when complementary requirements remain unsatisfied (Guo & Wu, 2019). Consequently, synchronization should evaluate material groups associated with production orders rather than treating each procurement requirement independently.

Fifth, adaptive feedback improves the conceptual resilience of the system. A static plan can become invalid when supplier delivery dates, demand, inventory, or production conditions change. Continuous feedback allows procurement priorities and production schedules to be recalculated. This finding directly reinforces the integrated SAP production-planning and procurement-synchronization perspective proposed by Kalal (2026).

The model therefore suggests that the principal value of synchronization is not merely faster information exchange. Its greater contribution is the conversion of operational information into coordinated decisions. A synchronized SAP environment can potentially reduce the time between identifying a supply constraint and determining its production consequence. However, the findings remain conceptual. They do not establish quantified improvements in cost, lead time, inventory, or service level because no empirical SAP dataset was used.

DISCUSSION

The findings indicate that production-procurement synchronization should be understood as a decision-coordination problem rather than solely as an ERP integration problem. Conventional integration may allow production and procurement data to coexist in one system, but adaptive management requires the system to interpret

relationships among those data. This distinction is important because information availability does not automatically produce optimal decisions.

The theoretical contribution of the framework is its integration of optimization and network perspectives into a supply chain synchronization context. Combinatorial optimization explains why competing production and procurement alternatives require structured decision mechanisms (Du et al., 2022). Constrained maximization further demonstrates the relevance of allocating limited resources according to value and feasibility (Sviridenko, 2004). Network studies contribute another dimension by showing why the impact of a particular node can depend on its position within a connected system (Alan et al., 2018; Leskovec et al., 2007).

The findings also highlight a critical trade-off between global optimization and local operational simplicity. A highly sophisticated priority mechanism may theoretically improve resource allocation but can become difficult for planners to interpret and maintain. Conversely, a simple first-come-first-served procurement mechanism is operationally easy but may ignore the systemic consequences of shortages. The proposed weighted-priority architecture attempts to balance these opposing requirements.

Another important issue is complementarity. Guo and Wu (2019) show conceptually why products or resources may derive value through interaction. In manufacturing, the same principle means that procuring one component does not necessarily create production capability unless the required complementary components are also available. Therefore, synchronization mechanisms should assess production feasibility at the bill-of-material or production-order level.

The framework also supports the resilience argument presented by Kalal (2026). Resilience should not be interpreted only as recovery after disruption. An adaptive synchronization system can contribute to resilience by identifying dependencies earlier, reallocating constrained resources, and modifying production plans before shortages become severe.

Nevertheless, the framework has limitations. It does not provide an empirical benchmark, real SAP configuration, supplier dataset, or computational complexity analysis. The optimization parameters and weighting factors are conceptual and would require calibration for specific industries. Furthermore, supplier behavior, transportation disruption, demand uncertainty, and human planner intervention may introduce conditions that cannot be represented adequately by a deterministic priority model.

Future research should therefore implement the framework in a real or simulated SAP S/4HANA environment and

compare synchronized planning against conventional planning. Scenario-based experiments involving supplier delays, demand volatility, material shortages, and capacity constraints could determine whether the proposed architecture produces measurable improvements in resilience, inventory efficiency, and production continuity.

CONCLUSION

This study developed a conceptual SAP S/4HANA-based Production and Procurement Synchronization Model for adaptive supply chain management. The central proposition is that production planning and procurement should operate as a coordinated decision system in which material availability, production criticality, supplier constraints, and downstream dependencies are evaluated simultaneously.

The theoretical synthesis demonstrates that concepts from combinatorial optimization, constrained maximization, network influence, and complementary-resource decision-making can support the development of such a framework. The proposed architecture introduces production requirement analysis, material availability evaluation, procurement prioritization, synchronization control, and adaptive feedback as interconnected mechanisms.

The principal contribution is the conceptual integration of optimization-oriented decision logic with SAP-centered production and procurement coordination. This perspective is consistent with the resilience-oriented integration emphasized by Kalal (2026). However, the study remains conceptual and therefore cannot claim quantified operational improvements. Empirical implementation and simulation are necessary to validate the framework.

Future research should focus on real-world SAP S/4HANA deployment, optimization algorithm development, machine-assisted priority determination, disruption simulation, supplier-risk integration, and comparative performance measurement. Such research could establish whether synchronized production-procurement planning can provide measurable improvements in supply chain responsiveness, inventory utilization, production continuity, and resilience.

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