Journal of Information Systems Engineering and Management
2021, 6(4)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

The Symbiotic Six Sigma–ERP Nexus: A Data-Intensive Framework for Supply Chain Excellence

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ARTICLE INFO

Received: 20 Aug 2021

Accepted: 05 Nov 2021

ABSTRACT

This paper proposes a Symbiotic Six Sigma-ERP Nexus, an information-intensive framework intended to achieve excellence in Supply Chain Management for SAP-based procurement. The research article will close the long-standing gap between the isolated implementation of Enterprise Resource Planning (ERP) systems and Six Sigma systems, both of which are essential to operational efficiency. Using a conceptual modelling methodology based on process analytics, the framework outlines the levels of interaction Process, Data, and Decision in a manner that structures the incorporation of Six Sigma principles, e.g., DMAIC, into ERP capabilities, e.g., SAP MM/PP modules.

The main findings support the idea that this nexus enables real-time performance monitoring, data-driven decision-making, and mapping Six Sigma measurements to essential ERP processes. Managerial implications include increased efficiency of the procurement cycle, improved inventory turnover, and reduced lead times, providing a practical roadmap for organizations seeking integrated operational and supply chain performance through a single data infrastructure.

Keywords: Six Sigma, ERP Integration, SAP, Lean Process Synergy, Supply Chain, Procurement

INTRODUCTION

Enterprise Resource Planning (ERP), especially SAP, and Six Sigma methodologies are the initial pillars for realizing operational excellence in contemporary organizations. ERP systems are integrated information systems that streamline core business processes, including finance, manufacturing, and Supply Chain Management. In contrast, Six Sigma offers an information-intensive approach to process optimization and defect elimination. Although each of these strong tools has been proven effective, organizations often use them in fragmented ways, preventing the creation of value synergies. Such fragmentation can lead to disjointed data streams, imperfect process operations, and failure to leverage real-time operational knowledge to drive continuous improvement programs. The overarching research issue is thus the untapped potential of an integrative framework that synthesizes the standardization of processes and the data-capture capabilities of ERP and Six Sigma, with strict improvement and analysis phases, especially in complex supply chain contexts.

To address the critical gap, this paper suggests a new, highly data-intensive Symbiotic Six Sigma ERP Nexus. The need to establish a conceptual framework to integrate Six Sigma principles and ERP capabilities smoothly, thereby improving supply chain performance, will be identified as the primary goal. To do so, some of the most important questions to be answered in the course of the research include: How can Six Sigma metrics be systematically mapped onto ERP workflow? What are the critical interaction layers needed in the symbiotic relationship between these two systems? What are the particular managerial consequences concerning the procurement and supply chain performance following such an integration? This research is mainly conceptual, focusing on the architectural structure of the nexus, with specific reference to the SAP Material Management (MM) and Production Planning (PP) modules, which are core to supply chain activities. The paper is organized as follows: a review of pertinent literature;

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a detailed description of the methodological approach; the proposed framework; a discussion of its implications; and, finally, conclusions with directions for future research.

LITERATURE REVIEW

Six Sigma supplies the missing discipline. The Define, Measure, Analyze, Improve, Control Cycle offers a concrete path from problem framing to sustained control. Teams clarify defects and customer-critical attributes, validate measurement systems, test hypotheses, and maintain gains through standard work and visual management. The method travels well because it comes with belts, charters, reviews, and coaching routines that scale across functions. In day-to-day practice, projects often sit outside the enterprise platform. Analysts export tables to spreadsheets, run macros, build ad hoc datasets, and store models on shared drives. Insights become detached from the transactions that run the business, and lessons fade when teams rotate to the next priority.

Prior scholarship has attempted to bridge the two domains. Many studies use ERP history to baseline yield, on time in full, or cost to serve during the Measure phase. Other work brings Six Sigma routines to ERP implementations to contain scope, improve data migration quality, and stabilize cutovers. These contributions deliver value, yet they still treat ERP as a passive data source or treat Six Sigma as a project wrapper around a technology change (Macias-Aguayo *et al.,* 2021). A symbiotic view asks for more and sets a higher bar. In that view, ERP and Six Sigma share a common logic, alerts, thresholds, and corrective actions that live within the flow of work.

A clear research gap follows from this observation. Modern supply chains move in hours, not quarters. Suppliers shift promise dates, carriers rebalance capacity, and forecasts flex with promotions or weather. Existing frameworks rarely embrace streaming events, exception queues, or constraint changes that matter this week. A unified, data-intensive framework would embed the DMAIC cycle within the ERP layer, enabling the organization to sense, diagnose, and correct in the same screens where orders, plans, and confirmations are executed. Define would translate strategic outcomes into platform-level critical quality attributes with explicit targets and tolerances. Measure would rely on native tables and event logs rather than fragile extracts, with a governed semantic layer that clarifies lineage and timing.

Analyze would fuse process mining with statistical tests to locate bottlenecks, rework loops, and defect clusters at the level of document flows and user actions. Root causes would be validated using capability analysis, regression, or nonparametric tests that reflect the actual work sequence. Improvements would trigger controlled configuration changes, workflow steps, or guided actions inside the transactions that generate value (Hill *et al.,* 2017). Control would embed control charts, Pareto diagrams, capability indices, and automated alerts into role-based workspaces, so deviations are flagged and corrected at source. This strategy transforms the system, which was accountable for the past, into a machine that governs change in the future.

The pattern is depicted through procurement. A team has targets for lead time variability, confirmation lag, and invoice accuracy. The platform sends purchase order modifications, inbound delivery messages, and goods receipt approval messages into a controlled Measure layer. Process discovery indicates approval lines and price adjustments that enhance variance (Sutduean *et al.,* 2019). Improvement modifies the release plans, triggers supplier quality processes, and tunes safety time buffers. Control monitors the standard deviation of lead time and sends alerts to buyers whenever thresholds are met, and associates them with directed actions that may require confirmation, expeditions, or the opening of corrective activities with suppliers.

The same applies to production and logistics. Shop floor confirmations support capability analysis at bottleneck work centres using near-real-time cycle data. Warehouse tasks yield pick accuracy and dwell time distributions by zone, carrier, and shift. Customer service screens expose promise date shifts, revealing plan instability and upstream constraint changes. When these signals are routed through an embedded Six Sigma lens, the organization detects drift earlier, reduces handoffs, and locks in gains through configuration rather than temporary workarounds.

The nexus also requires sound architecture and governance. Reliable master data stewardship keeps identifiers stable and hierarchies clean. A semantic layer clarifies definitions for service level, scrap, backlog, and yield so teams debate outcomes, not columns. Event-driven pipelines publish timely facts for analysis without duplicating systems of record. Role-based workspaces host the measures and guided actions that matter for planners, buyers, schedulers,

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supervisors, and customer agents. Access controls and audit trails protect sensitive data while still enabling transparent improvement.

This integration reshapes roles and routines. Black Belts and data engineers collaborate with process owners and solution architects. Charter templates reference ERP objects and transaction codes, not only abstract processes. Improvement backlogs sit alongside configuration backlogs, so changes to tolerances, buffers, or workflows follow the same release rhythm as features. Training teaches line leaders to read a control chart and to raise a change that adjusts a tolerance, a buffer, or a release strategy. Metrics roll up from stable definitions into executive reviews that focus on variation, not vanity.

The proposed research builds on this rationale. It aims to formalize constructs, specify architectural patterns that enable the nexus, and test outcomes across purchasing, planning, manufacturing, and distribution cases. The goal is a repeat, theory-supported strategy that transforms disjointed initiatives into an integrated operating model. In that model, ERP becomes an evidence-driven, adaptive control system, and Six Sigma serves as the rationale for holding it accountable and ensuring its functionality. The anticipated involvement is a pragmatic, data-intensive approach to sustainable supply chain execution that transforms local wins into organization-wide outcomes. That sets the agenda.

METHODOLOGY

The study has used a conceptual modelling methodology, supported by secondary data-driven analysis principles, to develop the Symbiotic Six Sigma-ERP Nexus. Such a design is especially applicable in the generation of new theoretical frameworks that would synthesize the current knowledge and suggest new relations among the already known systems. The methodology aims to outline the logical design, variables, and interaction processes of the proposed framework, drawing on insights into the operational realities of Supply Chain Management and the technical capabilities of ERP platforms and Six Sigma approaches.

The design logic of the framework lies in identifying key process touchpoints in a typical supply chain, such as procurement, inventory management, and logistics, where ERP data and the analytical rigor of Six Sigma can deliver remarkable benefits. Such variables are key performance indicators (KPIs) for lead time, defect rates, inventory turns, on-time delivery, and cost of poor quality, which are usually controlled by ERP systems and addressed by Six Sigma projects. The central assumption is that, by carefully interconnecting these variables, a more predictive and resilient operational environment can be developed.

The sources or informational materials for the information to be modeled in this conceptual model primarily rely on the functional requirements of the SAP Material Management (MM) and Production Planning (PP) modules (Jituri *et al.,* 2018). These modules provide more detailed specifications for purchase requisitions, purchase orders, goods receipts, inventory movements, production orders, and quality inspection logs. The framework identifies the potential for implementing Six Sigma metrics and control points in the ERP context by analyzing data structures and process flows across the following SAP modules (Moyano-Fuentes *et al.,* 2020).

The analysis instruments in the framework are primarily analysis tools compatible with the Six Sigma DMAIC stages, but recontextualized to accommodate real-time ERP integration. One such example is the “Measure” phase that exploits the automatic form of data extraction within the SAP; the “Analyze” phase which makes use of embedded data visualization and statistical process control (SPC) charts that are generated on the ERP data; the better part where the process is re-engineered based on the insights and implemented within the ERP environment; and the final phase, the Control phase that installs automated monitoring and alert functionality based on the ERP functionality (Rodrigo Subirá Conceição *et al.,* 2019). The soundness of this conceptual framework is primarily defined by its rational consistency, conformity with the canons of Six Sigma and ERP, and its ability to address the research gaps identified. They are the lack of empirical validation of a live implementation (which cannot be done within the scope of this conceptual work) and the generalization of SAP MM/PP to ERP ecosystems.

PROPOSED FRAMEWORK

The Symbiotic Six Sigma-ERP Nexus model proposes a multi-layered integration framework to remake supply chain operations through real-time process improvements enabled by data-intensive, real-time systems. This nexus is built

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on three main interaction layers: the Process Layer, the Data Layer, and the Decision Layer, all of which are vital to creating a smooth synergy between Six Sigma processes and ERP systems' capabilities.

Process Layer

This layer aims to overlay the Six Sigma DMAIC phases onto the primary ERP process. An example is in the procurement cycle, where the process of defining sets the boundaries for the procurement process and customer requirements in SAP MM. Measuring is the process of automatically extracting KPIs, such as purchase order cycle time, vendor lead-time variability, and defect rates, from SAP transactional data. This data is used in the embedded analytical tools of "Analyze" to determine the root causes of inefficiencies (e.g., through the reporting functionality of SAP, supplemented by statistical process control charts). Enhance Improve entails making amendments to workflow setups or master data in SAP based on predefined remedies, and Control ensures consistent monitoring with SAP notifications and dashboards to maintain enhancements. This layer states that Six Sigma is never an extrinsic initiative but is part and parcel of ERP-driven processes.

Data Layer

This layer lies at the heart of the nexus and will ensure the quality and real-time data flow between the operational tasks recorded by the ERP and the analytical requirements of Six Sigma. It includes standardizing data definitions, ensuring data integrity in SAP, and using interfaces or embedded analytics tools to access and manipulate ERP data directly in Six Sigma metrics. This layer converts raw transactional data (e.g., date of goods receipt, SAP QM inspection results, SAP PP delivery schedules) into actionable information, eliminating manual data processing and shortening the time between data generation and processing (Tan *et al.*, 2021).

Decision Layer

The layer supports data-driven decision-making by providing managers with real-time insights and predictive analytics from combined Six Sigma and ERP data. Dashboards, notifications, and automated reports, whether built in or linked to SAP, display key KPIs and performance metrics, enabling timely interventions. For example, a spike in inventory holding costs (an ERP financial measure) will trigger a Six Sigma phase of analysis on inventory turnover rates (Six Sigma focus), using data from SAP MM/PP.

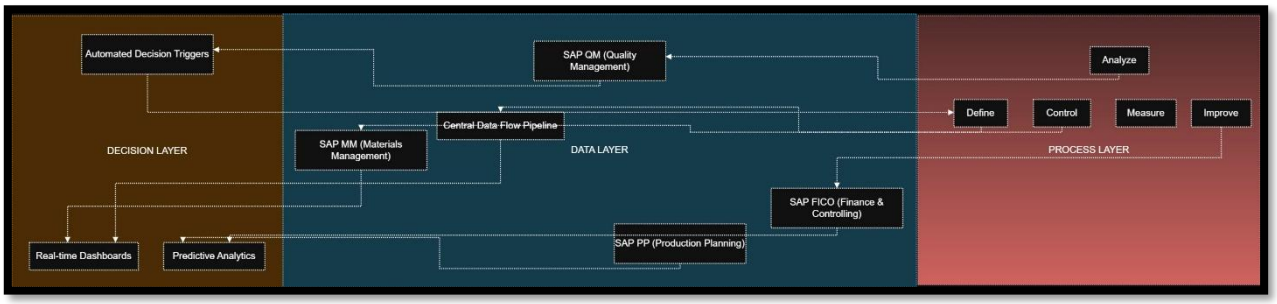

Figure 1: Conceptual Figure: Symbiotic Six Sigma–ERP Nexus

(Source: draw.io)

KPI	Six Sigma Linkage	ERP Module Source (SAP Examples)	Expected Impact
Purchase Order Cycle Time	Define, Measure (Process Efficiency)	SAP MM (Requisition to Payment)	Reduced Lead Time, Cost Savings

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KPI	Six Sigma Linkage	ERP Module Source (SAP Examples)	Expected Impact
Vendor Defect Rate	Measure, Analyze, Control (Quality)	SAP QM (Inspection Results)	Improved Product Quality, Supplier Performance
Inventory Turnover	Analyze, Improve (Waste Reduction)	SAP MM (Stock Levels, Consumption)	Optimized Working Capital, Reduced Obsolescence
On-Time Delivery (OTD)	Measure, Improve (Customer Satisfaction)	SAP SD, PP (Schedule Adherence)	Enhanced Customer Loyalty, Supply Chain Reliability
Cost of Poor Quality (COPQ)	Define, Analyze (Financial Impact)	SAP FICO, QM (Scrap, Rework Costs)	Direct Cost Reduction, Profitability

Table 1: Critical KPIs and Their Integration within the Nexus

This framework directly links Six Sigma metrics to ERP processes, enabling a continuous improvement loop that, of course, is inherently data-intensive and directly affects operational KPIs such as reduced procurement cycles, optimized inventory turnover, and significant lead-time improvements.

DISCUSSION AND IMPLICATIONS

The offered Symbiotic Six Sigma – ERP Nexus is an excellent step toward unifying two traditionally opposed paradigms of operational improvement, with immense implications for lean synergy and the endurance of continuous improvement in Supply Chain Management. By installing the Six Sigma rigorous, data-driven, analytical cycle specifically in SAP, the framework is transforming responsive management into a real-time, proactive, operational-excellence procedure (Ru *et al.,* 2018). Such an intensive integration will ensure that deviations within the process are not only identified but also systematically addressed, as in the Six Sigma approach to analysis, in line with the overall data background of ERP.

Elimination of data silos and manual data extraction, which tend to plague Six Sigma projects, is one of the main advantages. The nexus makes ERP the ongoing 'Measure' step of DMAIC, which streams real-time data directly into analytical tools to detect variations and identify root causes. This smooth movement contributes to lean synergy by identifying and eliminating waste, whether excessive lead time, excess inventory, or production errors at the point of first detection in the operational environment. For example, instant monitoring of purchase order processing time in SAP MM, in combination with Six Sigma statistical process control charts, could immediately indicate a departure from the norm, and an "Analyze" and "Improve" cycle would be initiated before it was too late to affect production or customer delivery.

By comparing the nexus to current frameworks, it becomes clear that the nexus adds to them in a particular way. Although previous efforts tended to utilize ERP data as input to Six Sigma projects or to map Six Sigma onto ERP implementation, this framework goes a step further by conceptualizing Six Sigma as an ingrained capability within ERP (Bochek & Olson, 2020). It goes deeper into a tool-use approach to a systemic integration, where the ERP workflows are structured to support and be enhanced by Six Sigma principles. It implies that process standardization, one of the main goals of the ERP, is continually refined and optimized through the Six Sigma quality improvement cycle, resulting in operational processes that are truly dynamic and flexible.

The managerial lessons that can be learned from this nexus are enormous, particularly in SAP-based procurement. Six Sigma knowledge of SAP data can enable organizations to predict shorter procurement cycles through automated

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defect detection and process re-engineering. Optimization of reorder points and safety stock can be achieved by analyzing demand variability and supplier performance in SAP MM/PP using statistical methods.

CONCLUSION

This study has presented the Symbiotic Six Sigma-ERP Nexus, a data-driven model that integrates Six Sigma techniques and Enterprise Resource Planning systems, particularly SAP-based procurement, to enhance supply chain excellence. The framework outlines a Process, Data, and Decision layer that depicts how the DMAIC cycle of Six Sigma can be integrated into ERP operations to realize real-time operational enhancements. Its theoretical value lies in adhering to a single model that transcends fragmented use of these potent means, providing a pathway to the actual model of integrated operational excellence. In practice, the nexus ensures the effectiveness of the procurement cycle, higher inventory turnover rates, and significant reductions in lead times, all of which are directly dependent on supply chain performance and profitability.

The paper reiterates the significance of data in the never-ending pursuit of improvement. It demonstrates how such a formalized mix can capitalize on the overall information capabilities that ERP offers and the analytical acuity that Six Sigma can infuse. Even though such a conceptual framework provides a robust basis, in the future, it is possible to identify several avenues of research. Case studies or an experimental application across a broader range of industrial settings would be the most helpful way to empirically test the framework and determine whether it is practical and practicable.

Future research can examine how recent data analytics, such as Machine Learning (ML) and Artificial Intelligence (AI), can be used to predict, monitor, and automatically identify abnormalities in the nexus. Research on monitoring systems could also further mechanize the Control phase of DMAIC, bringing truly self-improving supply chain operations.

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