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Optimizing Manufacturing Supply Chains Using a Strategic Lean Six Sigma Framework: A Case Study

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Abstract: ***Manufacturing supply chains are increasingly vulnerable to disruptions, inefficiencies, and market volatility, necessitating enhanced resilience to remain competitive. This study explores the integration of Lean Six Sigma (LSS) with strategic planning to optimize supply chain operations and align them with broader organizational goals. The focus is on reducing waste, improving efficiency, managing risks, minimizing costs, enhancing product quality, and securing a sustainable competitive advantage. Additionally, the research examines LSS applications in developing countries, where resource limitations, market instability, and infrastructure gaps significantly affect supply chain performance. The aim is to identify strategies that improve efficiency, resilience, and competitiveness while supporting sustainable growth in these regions. The study highlights the synergies between LSS and strategic planning, especially in mitigating risks and enhancing adaptability. Using the DMAIC framework and key performance indicators (KPIs), it evaluates the impact of LSS on procurement, operations, inventory management, and customer satisfaction. A conceptual framework is proposed to integrate LSS and strategic planning across supply chain functions, ensuring alignment with long-term business goals. A case study of an Egyptian electrical control panel manufacturer demonstrates the practical application of this approach, showcasing improvements in key supply chain functions. The findings offer valuable insights for academics and practitioners seeking to enhance supply chain resilience, mitigate risks, and sustain a competitive advantage in a rapidly evolving global market. The study also provides actionable guidance on using LSS tools to optimize performance and align operations with strategic objectives.***

Keywords: Manufacturing, Supply Chain, Performance, Lean Six Sigma, Strategic Planning, KPIs, Operational Efficiency, Continuous Improvement

Abbreviations:
5S: Visual control approach
AI: Artificial intelligence
CRM: Customer relationship management
DMAIC: Define, measure, analyze, improve, and control
ERP: Enterprise resource planning
IoT: Internet of things
JIT: Just-In-Time
KPIs: Key performance indicators
LSS: Lean six sigma
NPS: Net Promoter Score
RFID: Radio-frequency identification
ROI: Return on investment
SCM: Supply chain management
SPC: Statistical Process Control
SRM: Supplier relationship management
SWOT: Strengths, weaknesses, opportunities, and threats
TWOS: Threats, weaknesses, opportunities, and strengths
VSM: Value stream mapping

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I. INTRODUCTION

Effective manufacturing supply chain management (SCM) is essential for delivering high-quality products efficiently and at competitive costs. Organizations must continuously optimize their supply chain processes in today's rapidly changing business environment to remain competitive. Integrating Lean Six Sigma (LSS) with strategic planning offers a robust framework for streamlining operations, eliminating waste, and aligning supply chain strategies with long-term goals such as profitability, customer satisfaction, and sustainable growth. This integration enhances efficiency, agility, and risk management, driving cost savings, improved product quality, and greater profitability. By aligning daily operations with strategic objectives, organizations can optimize resource allocation, minimize delays, and foster cross-functional collaboration, ultimately creating a more responsive and cost-effective supply chain. Furthermore, LSS's focus on continuous improvement fosters innovation, enabling organizations to adapt to emerging technologies and trends, strengthening supply chain resilience, and supporting long-term growth. Through this approach, organizations can achieve sustained success through measurable improvements that yield financial benefits (Gomaa, 2024, [1]).

Manufacturers today face challenges such as fluctuating demand, global competition, and supply chain disruptions. To remain competitive, a structured approach to SCM is critical. LSS, with its focus on process optimization and waste reduction, complements strategic planning to form a comprehensive framework for improving operational efficiency and aligning supply chain activities with long-term objectives. Effective SCM hinges on two key elements: process optimization and strategic alignment. LSS, through its proven methodology, eliminates waste, reduces inefficiencies, and minimizes variation. Tools such as the DMAIC (Define, Measure, Analyze, Improve, Control) framework help organizations improve product quality, streamline operations, and lower costs. Strategic planning ensures that operational activities align with long-term organizational goals, focusing on risk management, adaptability, and sustainable growth (Gomaa, 2024, [2]).

Despite the positive impacts of LSS and strategic planning on SCM individually, limited research exists on their combined application in manufacturing supply chains.

Integrating these methodologies presents a unique opportunity to address modern supply chain challenges, including inefficiencies, disruptions, and variability. When properly aligned, LSS and strategic planning can significantly enhance operational performance, fostering resilient, agile, and forward-thinking supply chains (Gomaa, 2023, [3]).

This study explores the integration of LSS and strategic planning to optimize manufacturing supply chains. It aims to show that aligning operational processes with strategic objectives—through continuous improvement driven by LSS and long-term planning facilitated by strategic planning—can enhance supply chain resilience and adaptability. The paper begins with a literature review on LSS and strategic planning, focusing on their roles in improving supply chain performance. It then examines the synergies between these methodologies and their complementary strengths in building more resilient supply chains. Using case studies and empirical evidence, the research explores how LSS and strategic planning contribute to cost reduction, quality improvement, and risk management.

By combining the operational excellence of LSS with the strategic foresight of long-term planning, this research proposes an innovative approach to building resilient, high-performing manufacturing supply chains. The integration of LSS and strategic planning offers a promising path for organizations to optimize operations, mitigate risks, and gain a competitive advantage in a rapidly evolving global market. This paper is structured as follows: Section 2 reviews the literature, Section 3 identifies research gaps, Section 4 outlines the methodology, Section 5 presents a case study, and Section 6 concludes with insights and recommendations for future research.

II. LITERATURE REVIEW

The integration of Lean Six Sigma (LSS) into Supply Chain Management (SCM) has become a critical research area due to its potential to enhance operational efficiency, reduce waste, and improve overall supply chain performance. As organizations face increasing pressure to optimize resource use, improve product quality, and lower production costs, LSS has emerged as a strategic tool to streamline supply chain operations.

As highlighted in Tables 1 and 2, numerous studies emphasize the benefits of incorporating LSS into SCM, especially in improving operational efficiency, reducing waste, and enhancing performance. Jauhar et al. (2012) [4] explored the synergistic effects of combining LSS with SCM, showing substantial improvements in product and process performance, leading to sustainable growth. Their findings indicate that LSS integration enhances cost efficiency and customer satisfaction—critical factors for maintaining competitiveness in dynamic markets.

Tortorella et al. (2017) [5] examined how LSS practices align with supply chain objectives, noting that while some practices create synergies, others may conflict, limiting their collective impact. Their study concluded that organizations must strategically select LSS practices that align with specific operational and supply chain goals. Similarly, Jakhar et al. (2018) [6] focused on the impact of lean production practices on sustainable supply chain performance, with an emphasis on green practices. They found that integrating lean and green practices significantly improves both environmental sustainability and operational efficiency, meeting the dual goals of sustainability and performance.

Duarte and Cruz-Machado (2019) [7] proposed a roadmap for transforming supply chains through an integrated green-lean approach, allowing companies to optimize resources while meeting the growing market demand for sustainability, thus securing a competitive edge. Gultom and Wibisono (2019) [8] identified key areas—such as supplier selection, production, logistics, and warehouse management—where LSS can significantly improve SCM efficiency by optimizing critical performance indicators (KPIs) such as inventory management, quality, and employee engagement. Garcia-Buendia et al. (2021) [9] reviewed lean supply chain management (LSCM) research from 1996 to 2018, identifying emerging trends like digital transformation and artificial intelligence within LSS. They recommended that future research explore how these technologies can be integrated with LSS to further enhance supply chain performance.

Gomaa (2022) [10] introduced a comprehensive framework for integrating LSS into manufacturing SCM, focusing on continuous improvement, waste reduction, and process optimization. This framework provides practical guidance for organizations looking to enhance SCM efficiency. Gomaa (2023) [3] expanded on this by presenting a holistic framework that aligns LSS practices with long-term business goals, ensuring that supply chain improvements are both sustainable and strategically focused. In 2024, Gomaa [1] further explored LSS integration in SCM, demonstrating its impact in reducing waste, minimizing defects, and shortening lead times, resulting in cost reductions and improved operational performance.

Despite these advancements, challenges persist, especially in the practical application of LSS within SCM in developing regions. Sinoimeri and Teta (2023) [11] addressed these challenges by introducing performance metrics and frameworks to assess supply chain effectiveness. They also emphasized the role of Industry 4.0 technologies in enhancing decision-making and operational performance, suggesting that digital tools can accelerate LSS adoption. Liu et al. (2024) [12] proposed a framework to enhance supply chain resilience and efficiency through optimized resource utilization, showing that LSS principles not only reduce costs but also enhance resilience, enabling organizations to better adapt to market disruptions. Emon et al. (2024) [13] examined the role of Supplier Relationship Management (SRM) in improving supply chain performance [14], highlighting the importance of long-term collaboration and supplier development [15], particularly in industries with complex supplier networks [16]. Their findings emphasized the need for robust SRM strategies to foster collaboration, reduce costs, and improve outcomes [17].

In conclusion, the integration of LSS into SCM has proven to be an effective strategy for improving efficiency, reducing waste, and enhancing overall performance. Research highlights the benefits of combining lean and green practices, incorporating digital tools, and aligning LSS with long-term business goals to achieve sustainable growth and competitiveness. However, challenges remain in bridging the

gap between academic research and practical implementation, particularly in resource-constrained and volatile environments.

Table 1: Summary of the Case Studies in SCM-LSS (from 2012 to 2024)

#	Author(s)	Year	Key Focus	Findings/Contributions
1	Jauhar et al. [4]	2012	Integration of LSS and SCM	Enhanced product and process improvements, long-term cost efficiency, and customer satisfaction, fostering sustainable operational growth.
2	Tortorella et al. [5]	2017	Alignment of LSS practices with SCM objectives	Not all LSS practices align with SCM; strategic selection of practices is critical to achieving synergies and avoiding conflicts.
3	Jakhar et al. [6]	2018	Lean production and sustainable SCM with green practices	Integration of lean and green practices enhances environmental sustainability and operational efficiency.
4	Duarte and Cruz-Machado [7]	2019	Green-lean transformation roadmap for SCM	Practical roadmap for achieving resource optimization and sustainability, offering a competitive advantage.
5	Gultom and Wibisono [7]	2019	Role of LSS in optimizing SCM performance	Identified four critical SCM areas (supplier selection, production, logistics, and warehouses) where LSS significantly improves efficiency.
6	Garcia-Buendia et al. [9]	2021	Review of lean supply chain management trends	Highlighted the rise of digital transformation and AI in LSS; recommended further exploration of technology integration for enhanced performance.
7	Gomaa [10]	2022	Framework for LSS-SCM integration	Framework prioritizing continuous improvement, waste reduction, and process optimization to boost supply chain performance.
8	Gomaa [3]	2023	Comprehensive LSS framework for SCM	Emphasized aligning LSS practices with long-term objectives to ensure sustainable improvements in supply chain performance.
9	Gomaa [1]	2024	LSS-SCM integration for manufacturing efficiency	Demonstrated LSS benefits in reducing waste, defects, and lead times, leading to cost reductions and improved operational performance.
10	Sinoimeri and Teta [11]	2023	SCM sustainability in developing countries	Introduced metrics and frameworks for SCM effectiveness; highlighted Industry 4.0 technologies for better decision-making and performance improvement.
11	Liu et al. [12]	2024	Resource optimization for SCM resilience	Showed that LSS principles enhance cost reduction and resilience, improving flexibility and response to market disruptions.
12	Emon et al. [12]	2024	Supplier relationship management (SRM) in SCM	SRM and supplier collaboration are critical for optimizing efficiency, reducing costs, and improving outcomes in complex supply chain environments.

Table 2: Summary of the SCM-LSS Review

Aspect	Details
Applications & Case Studies	- Integration of LSS in SCM enhances efficiency, reduces waste, and boosts overall performance. - Case studies, such as Jauhar et al. (2012), [4], show improvements in cost efficiency and customer satisfaction. - Gultom & Wibisono (2019), [7] highlight LSS improvements in supplier selection, logistics, and warehouse performance.
Recent Innovations	- Integration of Industry 4.0 technologies (e.g., AI, digital transformation) with LSS to drive decision-making and enhance performance. - Adoption of green-lean practices for improved sustainability and operational efficiency (Duarte & Cruz-Machado, 2019, [7]). - Use of digital tools and performance metrics to accelerate LSS adoption (Sinoimeri & Teta, 2023, [11]).
Challenges	- Difficulty in applying LSS in developing regions due to resource constraints. - Challenges in aligning LSS practices with specific operational and strategic goals (Tortorella et al., 2017, [5]). - Gap between academic theories and practical implementation, especially in volatile environments.
Research Gaps	- Lack of integration between LSS and emerging technologies like AI and digital twins for SCM optimization. - Limited research on LSS applications in resource-constrained settings, particularly in developing countries.
Future Directions	- Expanding research on AI, digital transformation, and other advanced technologies in LSS for SCM. - Greater focus on Supplier Relationship Management (SRM) to improve supply chain efficiency (Emon et al., 2024, [12]). - Developing frameworks for enhancing resilience and adaptability in turbulent environments (Liu et al., 2024).

III. RESEARCH GAP ANALYSIS

The application of Lean Six Sigma (LSS) in Supply Chain Management (SCM) has shown substantial potential in enhancing operational efficiency, minimizing waste, and improving customer satisfaction. However, several critical gaps hinder its broader and more effective implementation. These gaps, as highlighted in Table 3, include:

1. **Lack of Industry-Specific Case Studies**: Existing research mainly focuses on theoretical models of LSS in SCM, with limited industry-specific case studies. Practical case studies are essential for understanding the challenges and benefits of LSS implementation in various operational contexts.
2. **Absence of a Unified Framework Across SCM Functions**: Current LSS applications are often isolated to specific areas (e.g., production, procurement, or logistics). There is a need for a comprehensive framework that integrates LSS principles across all supply chain functions to achieve cohesive improvements across the entire supply chain.
3. **Inadequate Performance Metrics for Holistic Evaluation**: Traditional performance metrics such as cost reduction and lead time dominate the evaluation of SCM initiatives. However, these metrics fail to capture the broader impacts of LSS, including employee engagement, collaboration, and supply chain resilience. A more comprehensive set of Key Performance Indicators (KPIs) is needed to reflect both operational and strategic outcomes.
4. **Weak Integration of Strategic Planning with Operational SCM**: Many organizations struggle to align their day-to-day supply chain operations with broader strategic business objectives. This misalignment impedes the ability of supply chains to adapt to market changes and technological advancements. Further research is required to explore how LSS can be aligned with strategic SCM planning.
5. **Underexplored Role of LSS in Enhancing Resilience and Sustainability**: While LSS is recognized for its efficiency-improving capabilities, its potential to enhance supply chain resilience and sustainability—especially

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in response to global disruptions and environmental concerns—remains underexplored.

6. **Insufficient Focus on Employee and Stakeholder Engagement**: Successful LSS implementation requires active participation from employees and stakeholders at all levels. However, many studies overlook the development of strategies to foster a culture of continuous improvement and secure organizational buy-in during the LSS adoption process.

A. Proposed Framework to Address Research Gaps

This study proposes a Lean Six Sigma for Supply Chain Management (LSS-SCM) framework designed to integrate LSS principles across all supply chain functions while aligning them with strategic business goals. As shown in Table 4, the framework consists of the following components:

1. **Holistic Application of LSS Across Supply Chain Functions**: This component ensures that LSS principles are applied uniformly across all critical supply chain functions, such as procurement, operations, inventory management, and logistics. By promoting cross-functional collaboration, the framework eliminates inefficiencies and silos in operations.
2. **Alignment of LSS with Strategic Business Objectives**: The framework connects LSS initiatives to broader organizational goals, such as profitability, growth, and sustainability. It incorporates strategic planning tools to align operational improvements with long-term business strategies, and dynamic feedback loops to allow adjustments in response to changing market conditions.
3. **Expansion of Performance Metrics and KPIs**: While traditional metrics like cost reduction and lead time remain important, the framework introduces additional KPIs that capture the broader impacts of LSS. These include measures of employee engagement, stakeholder collaboration, supply chain resilience, and sustainability, such as waste reduction, carbon footprint, risk mitigation, and recovery speed. Real-time monitoring through digital dashboards ensures that performance is continuously tracked.
4. **Visual Representation of the LSS-SCM Methodology**: To make complex concepts more accessible, the framework includes simplified visualizations of LSS principles and an interactive, step-by-step implementation roadmap. This approach enhances clarity and helps organizations navigate the LSS adoption process with ease. The methodology is customizable to meet the specific needs of different industries.
5. **Actionable Insights and Clear Implementation Roadmap**: The framework provides a structured approach to LSS adoption, guiding organizations from assessment to execution and ongoing monitoring. It addresses common implementation challenges, such as resistance to change and resource constraints, and emphasizes the importance of employee and stakeholder engagement in fostering a culture of continuous improvement.

In conclusion, the proposed LSS-SCM framework offers a comprehensive, integrated approach to applying LSS principles across all supply chain functions. By aligning operational improvements with strategic objectives, expanding performance metrics to include sustainability and resilience, and providing a user-friendly methodology, this framework enables organizations to optimize supply chain performance. It also ensures effective implementation and long-term success by addressing key barriers and fostering engagement at all levels of the organization.

Table 3: Summary of the Research Gap Analysis

#	Identified Gaps	Details
1	Lack of Industry-Specific Case Studies	Theoretical models exist, but there is a lack of real-world, industry-specific case studies to guide practical application.
2	Absence of a Unified Framework for LSS Across SCM Functions	No comprehensive framework integrates LSS across all SCM functions; a holistic approach is needed to maximize performance.
3	Inadequate Performance Metrics for Comprehensive SCM Evaluation	Existing metrics focus mainly on cost and lead time. Broader KPIs, such as employee engagement and supply chain resilience, are needed.
4	Weak Integration of Strategic Planning with Operational SCM	Many organizations lack a connection between strategic planning and day-to-day operations, limiting adaptability and alignment with business strategies.
5	Underexplored Role of LSS in Enhancing Resilience and Sustainability	LSS's role in fostering supply chain adaptability and sustainability, especially in the face of disruptions, is under-researched.
6	Insufficient Focus on Employee and Stakeholder Engagement	Active engagement of employees and stakeholders in the LSS process is crucial but underexplored in SCM contexts.

Table 4: Summary of the Proposed Framework to Address Gaps

#	Proposed Framework	Key Components
1	Holistic Application of LSS Across SCM Functions	- Integrated approach across all functions to prevent inefficiencies - Customizable tools for different functions - Promotes cross-functional collaboration
2	Alignment with Strategic Business Goals	- Aligns LSS with business strategies (profitability, growth, sustainability) - Strategic planning tools and a feedback loop to monitor progress toward goals
3	Expansion of Performance Metrics and KPIs	- Includes operational, employee engagement, sustainability, and resilience KPIs - Real-time performance monitoring through digital dashboards
4	User-Friendly, Visual Representation of LSS-SCM Methodology	- Clear graphical representation of LSS-SCM - Interactive, step-by-step implementation roadmap - Customization options for various industries
5	Actionable Insights and Clear Implementation Roadmap	- Structured roadmap for LSS adoption - Overcoming common barriers like resistance to change - Emphasizes employee and stakeholder engagement

IV. RESEARCH METHODOLOGY

This study adopts a systematic approach to investigate the integration of Lean Six Sigma (LSS) and strategic planning to enhance supply chain resilience and performance. The methodology is outlined in Table 5 and consists of seven key steps, each addressing specific research objectives and yielding actionable insights for effective implementation:

1. **Business Overview and Current Situation Analysis**: This step involves a thorough analysis of the company's supply chain structure, operations, and challenges to establish a clear understanding of the current state. It identifies improvement opportunities, assesses alignment with organizational goals, and evaluates operational constraints and barriers to integrating LSS and strategic planning. Engaging key stakeholders—such as leadership and operational teams—ensures a holistic view of challenges and opportunities, creating a solid foundation for defining strategic objectives and actionable recommendations.
2. **SWOT Analysis**: A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is conducted to evaluate internal capabilities and external risks affecting the supply chain. This analysis identifies critical gaps and highlights opportunities to apply LSS tools and strategic planning to improve performance. It also uncovers potential risks and offers strategies for mitigation. Collaboration with stakeholders ensures that priority areas for improvement are pinpointed, providing the foundation for setting strategic objectives and KPIs.
3. **Strategic Objectives and KPIs**: In this step, clear strategic objectives are defined to enhance supply chain resilience, agility, and operational efficiency. Measurable Key Performance Indicators (KPIs) are established to track progress and assess the success of improvements. These KPIs are closely aligned with the company's long-term goals, ensuring that efforts are directed toward broader organizational priorities. The involvement of leadership ensures that objectives are practical, feasible, and in sync with the company's strategic vision, offering clear direction for future improvements.
4. **Improvement Recommendations**: Based on the SWOT analysis and established KPIs, targeted improvement recommendations are developed. These recommendations integrate LSS methodologies, such as process mapping, root cause analysis, and waste reduction, alongside strategic planning tools to optimize supply chain processes. The focus is on improving efficiency, reducing waste, and enhancing agility. Risk mitigation strategies—including predictive analytics and digital tools—are incorporated to further reinforce the robustness of the proposed improvements.
5. **DMAIC Framework Development**: A customized DMAIC (Define, Measure, Analyze, Improve, Control) framework is developed to implement the recommended improvements. This framework aligns with strategic objectives and KPIs, ensuring a structured approach throughout each phase. Key metrics, tools, and resources are identified to support the process, guaranteeing that improvements are both sustainable and measurable. A feedback loop is integrated into the framework to facilitate continuous monitoring and adjustment, ensuring alignment with business goals.
6. **Improvement Plan and Implementation**: This phase focuses on executing the recommended improvements via the DMAIC framework. Continuous monitoring ensures that the improvements align with KPIs and strategic objectives. Real-time data tracking, feedback loops, and cross-functional collaboration are critical for successful implementation. Engaging stakeholders from various departments ensures that improvements are seamlessly integrated into daily operations, fostering ownership and promoting effective adoption across the organization.
7. **Continuous Improvement**: The final phase emphasizes ongoing evaluation and refinement of strategies and processes. Continuous monitoring of KPIs ensures sustained improvements, enabling the supply chain to remain responsive to market changes. A culture of Kaizen (continuous improvement) is encouraged, with leadership and employees actively refining processes. This phase ensures that the supply chain remains resilient, agile, and prepared to address emerging challenges and opportunities.

This methodology offers a structured framework for optimizing supply chain performance through the integration of LSS and strategic planning. By following this approach, organizations can enhance operational efficiency, mitigate risks, and build a resilient, agile supply chain that aligns with long-term business goals. The focus on continuous improvement ensures that the supply chain remains adaptable, supporting sustainable growth and long-term competitiveness.

Table 5: Summary of the Proposed Research Methodology

#	Step	Description
1	Business Overview and Current Situation Analysis	Analyze the company's supply chain, operations, challenges, and alignment with organizational goals. Identify improvement areas and assess obstacles to integrating LSS and strategic planning.
2	SWOT Analysis	Evaluate internal capabilities and external risks using SWOT analysis. Identify gaps, opportunities, and risks, while involving stakeholders to prioritize areas for improvement.
3	Strategic Objectives and KPIs	Define clear objectives for supply chain resilience, agility, and efficiency. Establish measurable KPIs aligned with long-term business goals to guide the improvement process.
4	Improvement Recommendations	Develop targeted recommendations using LSS tools (e.g., process mapping, root cause analysis) and strategic planning methods. Focus on enhancing efficiency, agility, and risk mitigation.
5	DMAIC Framework Development	Create a customized DMAIC framework to implement improvements. Ensure alignment with objectives and KPIs, using key metrics, tools, and resources for measurable and sustainable outcomes.
6	Improvement Plan and Implementation	Execute improvements using the DMAIC framework. Monitor progress using real-time data and feedback loops. Engage stakeholders for seamless integration into daily operations.
7	Continuous Improvement	Emphasize ongoing evaluation and refinement of strategies. Nurture a culture of Kaizen (continuous improvement) to ensure sustained success, adaptability, and resilience.

V. CASE STUDY

This case study explores the integration of Lean Six Sigma (LSS) and strategic planning within the supply chain of an Egyptian electrical control panel manufacturer. It focuses on the first five steps: business analysis, SWOT evaluation, defining strategic objectives and KPIs, formulating improvement recommendations, and designing a customized DMAIC framework. These steps are vital for aligning operational processes with strategic goals, identifying areas for improvement, and establishing measurable objectives that drive effective transformation.

The remaining steps—implementation and continuous improvement—will be covered in future research, offering insights into practical execution and long-term sustainability. This phased approach ensures effective change management, allows for progress tracking, and enables the adaptation of strategies to evolving market dynamics, ultimately supporting continuous supply chain optimization and resilience.

A. Business Overview and Current Situation Analysis

This study investigates the integration of Lean Six Sigma (LSS) and strategic planning to optimize supply chain performance at AL-DAWLIA, a prominent Egyptian manufacturer of electrical control panels. Established in 1976, AL-DAWLIA operates three production facilities, employs over 300 skilled professionals, and holds certifications such as ISO 9001 (Quality Management), ISO 45001 (Occupational Health and Safety), and ISO 14001 (Environmental Management). In response to Egypt's rapid urbanization and large-scale infrastructure projects, such as the New Capital City and New Alamein City, the electrical panel industry is experiencing significant growth. To remain competitive amidst challenges like market competition, fluctuating raw material prices, and evolving regulatory requirements, AL-DAWLIA has adopted a comprehensive strategy combining LSS with strategic planning. This strategy aims to drive operational efficiency, reduce costs, and maintain consistent product quality, all while aligning with the company's long-term objectives.

The integration process begins with a thorough evaluation of AL-DAWLIA's supply chain structure, operations, and challenges. This foundational analysis provides crucial data-driven insights that inform a targeted improvement strategy. Key activities in this phase include supply chain mapping, which documents the entire supply chain—from suppliers and production sites to distribution channels and customer interactions. This process identifies critical nodes, dependencies, and vulnerabilities, offering a clear understanding of material, information, and financial flows. Next, performance evaluation assesses key performance indicators (KPIs) such as lead times, inventory turnover, service levels, and cost efficiency. This evaluation uncovers inefficiencies, bottlenecks, and redundancies that hinder the supply chain's performance.

The analysis also focuses on identifying both internal and external challenges impacting the supply chain. Internal factors, such as resource limitations, fragmented processes, and outdated technology, are assessed, along with external risks like supply disruptions, market volatility, and regulatory compliance. Stakeholder engagement—including interviews, workshops, and surveys with leadership, supply chain managers, and cross-functional teams—provides qualitative insights to complement the quantitative data. A technology and systems assessment will evaluate existing platforms such as ERP systems and forecasting tools, identifying opportunities to integrate advanced technologies like IoT, AI, machine learning, and predictive analytics to optimize supply chain processes further. The customer and market analysis explores customer expectations regarding delivery speed, customization, and sustainability, while also considering market trends and competitive dynamics. This ensures the supply chain remains responsive and adaptable to shifting demands.

The results from this phase will deliver a clear blueprint for improvement, providing a comprehensive understanding of AL-DAWLIA's supply chain structure, strengths, and weaknesses. Strategic improvement areas will be identified to enhance efficiency, agility, and resilience through the integration of LSS and strategic planning. Engaging stakeholders will foster alignment and ensure collective commitment to the improvement initiatives, while actionable recommendations, measurable KPIs, and long-term objectives will be established.

B. Proposed SWOT Analysis

A SWOT analysis is essential to evaluate the integration of Lean Six Sigma (LSS) with strategic planning for optimizing manufacturing supply chains. This framework helps identify internal strengths and weaknesses, along with external opportunities and threats, enabling informed decision-making. The aim is to leverage strengths, address weaknesses, capitalize on opportunities, and mitigate threats to improve supply chain efficiency, resilience, and adaptability. Table 6 presents the SWOT analysis for this integration.

i. Strengths

- Process Optimization: LSS fosters continuous improvement, eliminating waste and optimizing resource utilization to enhance operational efficiency.
- Strategic Alignment: Integrating LSS with strategic planning aligns supply chain improvements with long-term business goals, driving growth, profitability, and customer satisfaction.
- Resilience and Agility: LSS enables the development of agile supply chains that can quickly adapt to market changes and disruptions, ensuring sustained performance.
- Competitive Advantage: By focusing on operational excellence, LSS strengthens customer satisfaction and enhances market positioning.
- Sustainability: LSS encourages sustainable practices through resource optimization and waste reduction, contributing to environmental and social responsibility goals.

ii. Weaknesses

- High Initial Costs: The upfront investment in training, technology, and systems required for LSS integration can be substantial, posing financial challenges.
- Resistance to Change: Employees and stakeholders may resist adopting new processes and technologies, which could slow the integration process.
- Implementation Complexity: Successful LSS integration requires skilled personnel,

detailed planning, and robust systems, making implementation complex.
- Delayed Benefits: The results from LSS integration may take time to materialize, making it difficult to gauge short-term performance improvements.

iii. Opportunities

- Technological Advancements: AI, IoT, automation, and other innovations offer significant potential to enhance the integration of LSS and improve supply chain performance.
- Global Expansion: The increasing complexity of global supply chains presents opportunities to streamline operations, improve efficiency, and scale operations.
- Shifting Customer Expectations: The growing demand for faster delivery, improved quality, and sustainable practices offers opportunities to align supply chain strategies with evolving customer needs.
- Proactive Risk Management: LSS enables better risk identification and mitigation, enhancing supply chain resilience and competitiveness in an uncertain environment.

iv. Threats

- Market Volatility: Economic instability, geopolitical tensions, and global crises (e.g., pandemics) can disrupt even optimized supply chains, posing a threat to stability.
- Intense Competition: Rivals who adopt similar strategies may diminish the competitive advantage gained through LSS integration, reducing differentiation.
- Supply Chain Disruptions: External factors, such as raw material shortages and geopolitical tensions, can threaten supply chain efficiency and performance.
- Technological Risks: Increased reliance on advanced systems heightens vulnerability to system failures, cyber threats, and other technological challenges.

In conclusion, the SWOT analysis highlights that integrating LSS with strategic planning offers a powerful approach to optimizing supply chain performance. While strengths like process optimization and resilience provide a foundation for success, challenges such as high costs and resistance to change must be addressed effectively. Leveraging technological advancements and proactive risk management can mitigate external threats such as market volatility and supply chain disruptions.

Expanding upon the SWOT analysis, the TWOS (Threats, Weaknesses, Opportunities, Strengths) framework offers actionable strategies for effectively integrating Lean Six Sigma (LSS) with strategic planning. This approach emphasizes leveraging internal strengths and external opportunities while addressing weaknesses and mitigating threats to optimize supply chain performance. Key insights from the TWOS analysis, as presented in Tables 7 to 10, are as follows:

- Strengths + Opportunities: Leverage organizational strengths, such as process optimization and resilience, to capitalize on emerging technological advancements and opportunities for global expansion.
- Strengths + Threats: Mitigate external threats like supply chain disruptions and market volatility by focusing on LSS principles such as adaptability, continuous improvement, and proactive risk management.
- Weaknesses + Opportunities: Address internal weaknesses, including high implementation costs and resistance to change, by embracing advanced technologies and proactive strategies for risk management.
- Weaknesses + Threats: Overcome implementation challenges by investing in robust systems and optimizing processes, thereby reducing the impact of competition and technological risks.

In conclusion, the TWOS analysis highlights the importance of aligning LSS with strategic planning to create highly efficient, resilient, and sustainable supply chains. By strategically leveraging strengths, addressing weaknesses, and proactively managing opportunities and threats, organizations can enhance their competitiveness, adapt to dynamic market conditions, and secure long-term success in their supply chain operations.

Table 6: The Proposed SWOT Matrix

Strengths	Weaknesses
1. Process optimization leads to improved efficiency, reduced waste, and better resource use. 2. Strategic alignment with long-term business goals (growth, profitability, customer satisfaction). 3. Builds resilient, agile supply chains capable of adapting to disruptions. 4. Competitive advantage through operational excellence and customer satisfaction. 5. Promotes sustainability through resource optimization and waste reduction.	1. High initial investment in training, technology, and system upgrades. 2. Resistance to change from employees, hindering the adoption of new processes. 3. Complex implementation requiring skilled personnel and detailed strategy. 4. Time required to achieve full benefits and optimization.
Opportunities	Threats
1. Technological advancements (AI, automation, IoT) to enhance supply chain performance. 2. Global expansion increases demand for resilient, efficient supply chains. 3. Rising customer expectations for speed, quality, and sustainability. 4. Proactive risk management to anticipate and mitigate disruptions.	1. Market volatility and global events (e.g., pandemics, natural disasters, wars) disrupt supply chains. 2. Increased competition from organizations adopting similar practices and technologies. 3. Global supply chain disruptions such as raw material shortages or geopolitical tensions. 4. Technological risks including system failures and cybersecurity threats.

Table 7: TOWS Analysis - Threats and Weaknesses (T/W)

Threats	Weaknesses	Strategy
Market Volatility: Economic and geopolitical instability.	High Initial Investment: Upfront costs for training and technology.	Phased Implementation: Distribute costs over time and highlight long-term savings.
Intensified Competition: Competitors using similar approaches.	Resistance to Change: Pushback on new processes.	Change Management: Engage employees early and stress the efficiency benefits of LSS.
Supply Chain Disruptions: Raw material shortages, geopolitical tensions.	Implementation Complexity: Requires skilled personnel and resources.	Proactive Risk Management: Build a skilled workforce and manage disruptions effectively.
Technological Risks: System failures and cybersecurity threats.	Time to Realize Benefits: Delayed results from optimization.	Tech Resilience & Quick Wins: Strengthen systems and focus on achieving early, measurable res

Table 8: TOWS Analysis - Threats and Strengths (T/S)

Threats	Strengths	Strategy
Market Volatility: Economic and geopolitical instability.	Resilience & Agility: LSS enhances adaptability.	Enhance Agility: Foster continuous improvement for quick adaptation.
Intensified Competition: Competitors using similar LSS practices.	Competitive Advantage: Operational excellence and customer satisfaction.	Maintain Leadership: Differentiate with advanced LSS and a customer-first approach.
Supply Chain Disruptions: Raw material shortages, transport issues.	Sustainability: Focus on resource optimization and waste reduction.	Promote Sustainability: Leverage sustainability for resilience and stakeholder trust.
Technological Risks: System failures and cybersecurity threats.	Technological Integration: IoT, AI, and automation in LSS.	Strengthen Infrastructure: Invest in robust technology and cybersecurity.

Table 9: TOWS Analysis - Opportunities and Weaknesses (O/W)

Opportunities	Weaknesses	Strategy
Technological Advancements: AI, IoT, automation.	High Initial Investment: Training and tech integration costs.	Leverage Technology: Use tech to reduce long-term costs and justify initial investment.
Global Expansion: Access to new markets.	Resistance to Change: Reluctance to adopt new processes.	Training & Adaptability: Foster global best practices and adaptability through training.
Increasing Customer Expectations: Faster delivery, better quality, sustainability.	Delayed Benefits: Time needed for full LSS impact.	Quick Wins: Deliver early results (faster delivery, improved quality) to meet demands.
Proactive Risk Management: Mitigating disruptions.	Complex Implementation: Requires careful planning and skilled personnel.	Simplified Risk Management: Use LSS to identify and mitigate risks efficiently.

Table 10: TOWS Analysis - Opportunities and Strengths (O/S)

Opportunities	Strengths	Strategy
Technological Advancements: AI, IoT, automation for efficiency.	Strategic Alignment: LSS supports long-term goals.	Harness Technology: Integrate AI and automation within LSS to optimize and align processes.
Global Expansion: Expanding markets demand agility.	Resilience & Agility: LSS enables responsive supply chains.	Scale Agility: Use LSS to expand globally while maintaining resilience and adaptability.
Rising Customer Expectations: Demand for faster, high-quality, and sustainable solutions.	Competitive Advantage: Operational excellence and customer satisfaction.	Exceed Expectations: Leverage LSS for faster delivery and quality, differentiating from competitors.
Proactive Risk Management: Opportunities to mitigate disruptions.	Sustainability: Focus on waste reduction and resource optimization.	Sustainability for Risk: Use LSS's sustainability focus to proactively address risks and enhance resilience.

C. Proposed Strategic Objectives and KPIs

This section presents refined strategic objectives and Key Performance Indicators (KPIs) designed to optimize manufacturing supply chains. These objectives are crafted to improve efficiency, resilience, and alignment with organizational goals using Lean Six Sigma (LSS) methodologies. The key focus is on driving continuous improvement, mitigating risks, and optimizing performance across various functions including operations, procurement, inventory, financial management, market positioning, and risk management. Table 11 summarizes these strategic objectives along with specific, measurable KPIs.

i. Operational Efficiency

Strategic Objective: Enhance operational efficiency by minimizing waste, optimizing resource utilization, and ensuring consistent product quality.

KPIs and Targets:

- Product Quality Ratio
  - Definition: Percentage of products meeting established quality standards.
  - Target: Increase by 5% annually.
  - Measurement: Track using Statistical Process Control (SPC) charts and defect rates.
  - Action: Identify and eliminate root causes of defects.
- Production Capacity Utilization
  - Definition: Proportion of available production capacity effectively utilized.
  - Target: Achieve an 8% annual increase.
  - Measurement: Compare actual output to available capacity.
  - Action: Identify and address bottlenecks in the production process.
- Labor Productivity
  - Definition: Output produced per labor hour.
  - Target: Increase by 6% annually.
  - Measurement: Calculate output per labor hour across departments.
  - Action: Streamline workflows and provide continuous training to enhance worker efficiency.
- Value-Added Time Ratio
  - Definition: Proportion of

time spent on value-added activities versus non-value-added tasks.
- Target: Increase by 8% annually.
- Measurement: Conduct value stream mapping to identify and eliminate waste.
- Action: Eliminate non-value-added processes and focus on high-impact activities.

ii. Procurement Optimization

Strategic Objective: Streamline procurement processes to reduce lead times, cut costs, and strengthen supplier relationships.

KPIs and Targets:

- Supplier Lead Time
  - Definition: Average time taken for suppliers to deliver goods after an order is placed.
  - Target: Reduce by 6% annually.
  - Measurement: Track delivery performance for each supplier.
  - Action: Work collaboratively with suppliers to improve delivery schedules.
- On-Time Supplier Delivery
  - Definition: Percentage of orders delivered by suppliers on or before the agreed delivery date.
  - Target: Increase by 5% annually.
  - Measurement: Monitor supplier performance against delivery deadlines.
  - Action: Build closer relationships with suppliers to ensure timely deliveries.
- Procurement Cost Reduction
  - Definition: Reduction in total procurement costs.
  - Target: Achieve a 5% cost reduction annually.
  - Measurement: Regularly assess procurement practices and identify cost-saving opportunities.
  - Action: Negotiate better contracts and optimize sourcing strategies.

iii. Inventory Management Excellence

Strategic Objective: Optimize inventory management to balance cost control with material availability, reducing excess stock and stockouts.

KPIs and Targets:

- Material Stockout Ratio
  - Definition: Frequency of stockouts occurring in critical materials.
  - Target: Reduce stockouts by 5% annually.
  - Measurement: Use demand forecasting tools to predict material needs.
  - Action: Improve demand forecasting accuracy and set optimal reorder points.
- Inventory Turnover Ratio
  - Definition: Frequency at which inventory is sold and replaced during a period.
  - Target: Increase turnover by 10% annually.
  - Measurement: Track inventory movement and assess days sales of inventory (DSI).
  - Action: Improve inventory flow and reduce holding costs.
- Automated Inventory Management
  - Definition: Percentage of inventory management tasks automated to reduce manual effort.
  - Target: Increase automation by 8% annually.
  - Measurement: Implement technologies such as RFID and barcoding systems for tracking.
  - Action: Integrate advanced automated systems to enhance inventory accuracy.

iv. Financial Performance Optimization

Strategic Objective: Strengthen financial performance by reducing costs, improving margins, and ensuring effective cash flow management.

KPIs and Targets:

- Production Costs
  - Definition: Total costs incurred in producing products, including direct and indirect costs.
  - Target: Reduce by 5% annually.
  - Measurement: Regular cost audits to track cost-saving opportunities.
  - Action: Apply Lean principles to identify and eliminate cost inefficiencies.
- Storage Costs
  - Definition: Costs associated with warehousing, including space rental and inventory holding.
  - Target: Reduce by 5% annually.
  - Measurement: Optimize storage practices to maximize warehouse space utilization.
  - Action: Reduce excess inventory and improve storage management practices.
- Profit Margins
  - Definition: Percentage of revenue remaining after all production costs are deducted.
  - Target: Increase profit margins by 5% annually.
  - Measurement: Track profitability through financial reports and operational efficiency.
  - Action: Enhance product pricing, reduce waste, and optimize production processes.
- Value-Added Cost Ratio
  - Definition: Proportion of costs attributed to value-added activities, as opposed to non-value-added activities.
  - Target: Increase by 6% annually.
  - Measurement: Use process mapping to identify and focus on value-adding processes.
  - Action: Eliminate waste and streamline operations to increase focus on value-added tasks.
- Risk Mitigation Costs
  - Definition: Costs incurred in identifying and mitigating risks to business operations.
  - Target: Reduce by 5% annually.
  - Measurement: Evaluate the effectiveness and efficiency of risk management strategies.
  - Action: Enhance risk mitigation practices and adopt proactive strategies.

v. Market Competitiveness

Strategic Objective: Strengthen market position by improving customer satisfaction, ensuring timely deliveries, and fostering customer loyalty.

KPIs and Targets:

- Lead Time to Customers
  - Definition: Time taken from order receipt to final delivery to customers.

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- Target: Reduce by 6% annually.
- Measurement: Track lead times and improve logistics processes.
- Action: Streamline order processing and delivery systems for faster turnaround.

- On-Time Delivery to Customers
  - Definition: Percentage of orders delivered to customers on time, as per the committed schedule.
  - Target: Increase by 10% annually.
  - Measurement: Monitor delivery performance metrics.
  - Action: Optimize logistics and improve coordination with suppliers and distributors.
- Customer Satisfaction
  - Definition: Overall satisfaction of customers regarding products and services.
  - Target: Increase satisfaction levels by 5% annually.
  - Measurement: Use customer surveys, Net Promoter Score (NPS), and feedback forms.
  - Action: Address feedback promptly and focus on improving product quality and service.
- Customer Retention Rate
  - Definition: Percentage of repeat customers over a defined period.
  - Target: Increase retention by 5% annually.
  - Measurement: Monitor customer behavior and track loyalty.
  - Action: Develop loyalty programs and improve customer engagement strategies.

vi. Risk Management and Resilience

Strategic Objective: Strengthen risk management capabilities to reduce operational disruptions and improve business resilience.

KPIs and Targets:

- Risk Mitigation Effectiveness
  - Definition: Proportion of identified risks that are effectively mitigated.
  - Target: Achieve 95% effectiveness in risk mitigation strategies.
  - Measurement: Conduct risk assessments and track mitigation actions.
  - Action: Continuously monitor and improve risk identification and mitigation strategies.
- Business Continuity Planning (BCP) Effectiveness
  - Definition: Effectiveness of business continuity plans in ensuring minimal disruption during crises.
  - Target: Achieve 98% effectiveness.
  - Measurement: Regular BCP tests and evaluations.
  - Action: Conduct crisis simulations and update BCP protocols to ensure readiness.

Table 11: The Proposed Strategic Objectives and KPIs with Annual Targets

Area	Strategic Objective	Main KPIs with Annual Targets
1. Operational Management Performance	Enhance operational efficiency by reducing waste and optimizing resource utilization	- Product Quality Ratio: +5% - Production Capacity Utilization: +8% - Labor Productivity: +6% - Value-Added Time Ratio: +8%
2. Procurement Management Performance	Optimize procurement processes to reduce lead times, cut costs, and improve supplier relationships	- Supplier Lead Time: -6% - On-Time Supplier Delivery: +5% - Procurement Cost Reduction: -5%
3. Inventory Management Performance	Improve inventory management for better cost control and material availability, reducing excess stock	- Material Stockout Ratio: -5% - Inventory Turnover Ratio: +10% - Automated Inventory Management: +8%
4. Financial Management Performance	Improve financial performance by reducing costs, enhancing margins, and optimizing cash flow management	- Production Costs: -5% - Storage Costs: -5% - Profit Margins: +5% - Value-Added Cost Ratio: +6% - Risk Mitigation Costs: -5%
5. Market Management Performance	Strengthen market position by improving customer satisfaction, ensuring timely deliveries, and boosting loyalty	- Lead Time to Customers: -6% - On-Time Delivery to Customers: +10% - Customer Satisfaction: +5% - Customer Retention Rate: +5%
6. Risk Management and Sustainability Performance	Enhance risk management strategies to minimize disruptions and ensure business continuity	- Risk Mitigation Effectiveness: 95% - Business Continuity Planning (BCP) Effectiveness: 98%

D. Improvement Recommendations

This section presents improvement recommendations that are aligned with the strategic objectives and KPIs previously discussed. By leveraging Lean Six Sigma (LSS) methodologies and strategic planning tools, the goal is to optimize the manufacturing supply chain. These recommendations are designed to enhance operational efficiency, reduce costs, mitigate risks, boost customer satisfaction, and ensure sustainability—while remaining in line with long-term business objectives. Table 12 outlines the key improvement strategies for each critical area of the supply chain, with an emphasis on performance enhancement and resilience.

i. Optimizing Operational Management

Objective: Enhance operational efficiency and product quality. Recommendation: Implement Lean Six Sigma tools such as Value Stream Mapping (VSM), 5S, and Statistical Process Control (SPC) to streamline operations and improve performance. Expected Impact: Improved production capacity utilization, reduced waste, and higher labor productivity. Actionable Steps:

- Use VSM to identify bottlenecks and eliminate waste in the production process.
- Apply 5S to organize workspaces, minimize waste, and ensure that only necessary materials are available.
- Utilize SPC to monitor and control key production processes for consistent product quality. Control Steps:
- Track key metrics such as downtime, defects, and throughput.
- Use SPC to ensure ongoing quality improvements.

- Provide continuous training on Lean Six Sigma principles and best practices.

ii. Enhancing Procurement Management

Objective: Optimize procurement processes to reduce costs and enhance supplier relationships. Recommendation: Utilize RFID technology and predictive analytics to improve collaboration with suppliers, reduce lead times, and enhance procure-ment efficiency. Expected Impact: Shortened lead times, improved on-time delivery, and stronger supplier relationships. Actionable Steps:

- Implement RFID for real-time tracking of materials, improving sourcing efficiency.
- Use predictive analytics to better forecast demand and adjust procurement schedules to reduce supply disruptions.
- Establish long-term relationships with suppliers through strategic contracts to ensure reliability and reduce procure-ment costs. Control Steps:
- Continuously evaluate supplier performance using scorecards.
- Monitor cost savings and lead-time reductions.
- Assess suppliers' sustainability practices and compliance.

iii. Improving Inventory Management

Objective: Optimize inventory levels to reduce costs and improve material availability. Recommendation: Integrate Just-In-Time (JIT) principles with automated inventory systems and big data analytics to op-timize inventory control, reduce waste, and improve responsiveness to demand fluctuations. Expected Impact: Increased inventory turnover, reduced stockouts, and better utilization of automated inventory systems. Actionable Steps:

- Implement JIT to align inventory with production schedules, minimizing storage costs.
- Use ERP systems for automated inventory management and demand-driven restocking.
- Leverage big data analytics to optimize stock levels, improve reorder points, and minimize excess inventory. Control Steps:
- Conduct regular audits to compare stock levels with forecasts.
- Monitor stockouts and adjust planning accordingly.
- Continuously evaluate the performance of replenishment algorithms.

iv. Optimizing Financial Performance

Objective: Control costs and improve financial forecasting to enhance profitability. Recommendation: Apply Lean Six Sigma techniques to reduce production costs, enhance labor productivity, and lower storage costs. Expected Impact: Reduced production and storage costs, improved profit margins. Actionable Steps:

- Use Pareto Analysis and Fishbone Diagrams to identify cost drivers and opportunities for cost reduction.
- Improve labor productivity by 12% through optimized workflows and targeted training programs.
- Streamline warehouse management by improving space utilization and automating inventory processes. Control Steps:
- Regularly review financial performance through audits and benchmarking.
- Track cost savings and measure profitability improvements.
- Assess the return on investment (ROI) for optimization initiatives.

v. Improving Customer and Market Management

Objective: Enhance customer satisfaction and strengthen market position. Recommendation: Improve on-time delivery and customer satisfaction through more accurate demand forecasting, real-time order tracking, and effective feedback loops. Expected Impact: Higher on-time delivery rates, improved customer satisfaction, and reduced customer churn. Actionable Steps:

- Use machine learning algorithms for enhanced demand forecasting and production scheduling.
- Implement real-time order tracking to increase transparency and improve the customer experience.
- Gather and analyze customer feedback to continuously improve service quality and retention strategies. Control Steps:
- Measure customer satisfaction using surveys and Net Promoter Scores (NPS).
- Track customer retention and monitor churn rates.
- Evaluate fulfillment accuracy and resolve delays promptly.

vi. Strengthening Risk Management and Sustainability

Objective: Improve risk management to enhance operational resilience and integrate sustainability practices. Recommendation: Proactively implement risk mitigation strategies and integrate sustainability initiatives to ensure long-term competitiveness. Expected Impact: Enhanced risk mitigation and adoption of sustainability practices. Actionable Steps:

- Conduct comprehensive risk assessments to identify vulnerabilities, including supply chain disruptions and geopo-litical risks.
- Integrate sustainability practices, such as reducing packaging waste, adopting renewable energy, and ensuring sup-plier sustainability compliance.
- Develop contingency plans for major risks to minimize disruptions. Control Steps:
- Conduct regular risk assessments and refine mitigation strategies.
- Monitor the effectiveness of risk mitigation measures and adjust as needed.
- Track the impact of disruptions and adapt quickly.

vii. Aligning Long-Term Strategic Objectives

Objective: Align supply chain management (SCM) operations with long-term strategic objectives for growth, agility, and resilience. Recommendation: Regularly review KPIs and foster a culture of continuous improvement to ensure supply chains remain agile and responsive to market changes. Expected Impact: Enhanced growth, agility, and resilience in response to market dynamics. Actionable Steps:

- Regularly review and update KPIs to ensure they align with evolving business goals.
- Foster a Kaizen-driven culture of continuous improvement across all teams.
- Empower teams to adapt quickly to demand shifts and disruptions. Control Steps:
- Continuously track and review KPIs to measure performance.
- Ensure alignment of strategic goals with market conditions.

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- Monitor employee engagement and responsiveness to disruptions.

These improvement recommendations offer a structured, holistic approach to optimizing supply chain performance. By leveraging Lean Six Sigma methodologies, advanced technologies, and strategic planning, organizations can enhance operational excellence, resilience, and long-term adaptability. These recommendations not only prioritize efficiency and cost reduction but also focus on customer satisfaction, sustainability, and overall agility, positioning organizations for sustained success in a competitive and dynamic market.

Table 12: Summary of Improvement Recommendations

#	Area	Main Improvement Recommendations
1	Operational Management	- Integrate Lean Six Sigma tools (VSM, 5S, SPC, … etc.) to enhance operational efficiency and product quality. - Identify and eliminate production bottlenecks to maximize throughput.
2	Procurement Management	- Utilize RFID technology for real-time material tracking to enhance procurement efficiency. - Foster long-term supplier relationships to reduce lead times and procurement costs.
3	Inventory Management	- Implement Just-In-Time (JIT) and automated inventory systems to optimize stock levels and reduce storage costs. - Leverage big data analytics for better demand forecasting and inventory optimization.
4	Financial Management	- Apply Lean Six Sigma to reduce production costs and improve labor productivity. - Optimize warehouse space and automate processes to reduce storage costs and improve profit margins.
5	Market Management	- Utilize data analytics for demand forecasting and market trend analysis. - Strengthen customer engagement through personalized marketing strategies and strategic partnerships.
6	Customer Satisfaction	- Improve on-time delivery and service transparency through real-time order tracking. - Continuously gather customer feedback to improve service quality and enhance retention.
7	Risk Management	- Conduct regular risk assessments to identify vulnerabilities and mitigate supply chain risks. - Integrate sustainability practices to reduce risks and ensure long-term operational resilience.

E. Proposed DMAIC Framework

Integrating Lean Six Sigma (LSS) with strategic planning optimizes manufacturing supply chains, ensuring alignment with long-term business objectives. This framework enhances efficiency, resilience, and agility, promoting sustainable growth. As shown in Table 13, the phases below outline the process:

i. *Define Phase:* Aligning Objectives with Strategic Goals Establish clear, measurable objectives aligned with strategic business goals, targeting areas like quality, lead time, and customer satisfaction.

Key Activities:
- Identify key supply chain areas (e.g., procurement, production, logistics).
- Align objectives with business priorities.
- Engage stakeholders across departments.
- Define project scope and select KPIs (e.g., on-time delivery).

ii. *Measure Phase:* Data Collection and Strategic Insights Gather and analyze data to assess current performance and uncover inefficiencies, ensuring alignment with strategic goals.

Key Activities:
- Collect data on supply chain performance (e.g., lead times, inventory).
- Establish performance baselines.
- Utilize tools like Pareto analysis and Value Stream Mapping (VSM) to identify inefficiencies.

iii. *Analyze Phase:* Root Cause Analysis with Strategic Focus Identify and address root causes of inefficiencies using tools like 5 Whys and Fishbone diagrams. Focus on areas that impact long-term business goals.

Key Activities:
- Conduct root cause analysis for identified inefficiencies.
- Quantify the impact of inefficiencies on key metrics (e.g., cost, quality).
- Prioritize issues and eliminate non-value-added activities.

iv. *Improve Phase:* Lean and Six Sigma Solutions with Strategic Alignment Implement Lean and Six Sigma tools to eliminate waste, reduce variation, and improve processes, ensuring alignment with strategic objectives.

Key Activities:
- Apply Lean principles (e.g., Just-In-Time, Kaizen) to eliminate waste.
- Use Six Sigma tools (e.g., process redesign, control charts) to improve consistency.
- Leverage technology (e.g., automation, predictive analytics) to optimize operations.
- Strengthen supplier relationships for improved lead times and product quality.

v. *Control Phase:* Ensuring Sustainability through Strategic Monitoring Monitor and sustain improvements through continuous tracking, audits, and ongoing training, ensuring alignment with evolving business goals.

Key Activities:
- Track KPIs to ensure consistent performance.
- Develop new Standard Operating Procedures (SOPs) to standardize improvements.
- Collect feedback and perform regular audits.
- Provide ongoing Lean Six Sigma training for continuous improvement.

Key Benefits:
- Alignment with Business Strategy: Ensures that improvements directly support organizational goals, maximizing impact.
- Enhanced Risk Management: Improves the ability to anticipate and mitigate risks.
- Increased Agility: Enables quick adaptation to market changes and customer demands.
- Sustained Competitive Advantage: Drives cost savings, improves quality, and maintains competitiveness.

By integrating Lean Six Sigma with strategic planning, this framework helps establish efficient, resilient supply chains that foster long-term success and sustainable growth while aligning with broader organizational goals.

Table 13: The Proposed LSS Framework

Phase	Objective	Key Activities	Role of Strategic Planning
Define	Align objectives with strategic business goals	- Identify key supply chain areas (e.g., procurement, production, logistics). - Align objectives with business priorities. - Engage cross-functional stakeholders. - Define project scope and select KPIs (e.g., on-time delivery).	Ensures alignment of improvement efforts with long-term strategic goals, guiding project focus and ensuring impact on critical areas.
Measure	Collect data and assess current performance	- Gather data on supply chain performance (e.g., lead times, inventory levels). - Establish performance baselines. - Use tools like Pareto analysis and Value Stream Mapping (VSM) to identify inefficiencies.	Provides insights into current performance, highlighting gaps and areas for improvement, driving data-driven decisions aligned with business objectives.
Analyze	Identify root causes of inefficiencies	- Perform root cause analysis using tools like 5 Whys and Fishbone diagrams. - Quantify impact on key metrics (e.g., cost, quality). - Prioritize issues and eliminate non-value-added activities.	Targets inefficiencies that directly affect strategic goals, ensuring that efforts are concentrated on the most impactful issues for long-term success.
Improve	Implement Lean and Six Sigma solutions aligned with strategy	- Apply Lean principles (e.g., Just-In-Time, Kaizen) to eliminate waste. - Use Six Sigma tools (e.g., process redesign, control charts) to improve consistency. - Leverage automation and predictive analytics to optimize operations. - Strengthen supplier relationships for better lead times and quality.	Delivers tangible improvements aligned with strategic priorities, driving operational efficiency, quality, and competitiveness.
Control	Ensure sustainability and continuous improvement	- Monitor KPIs to ensure consistent performance. - Standardize improvements with updated SOPs. - Collect feedback, conduct audits, and track progress. - Provide ongoing Lean Six Sigma training to sustain improvements.	Ensures ongoing alignment with business objectives, embedding continuous improvement into the organizational culture to support sustained growth and competitiveness.

VI. CONCLUSION AND FUTURE WORK

This study highlights the strategic integration of Lean Six Sigma (LSS) and strategic planning to optimize manufacturing supply chains, ensuring alignment with long-term business objectives. The approach not only enhances operational efficiency, reduces waste, and strengthens risk management but also fosters sustainable profitability. It addresses challenges faced by developing countries, such as limited resources and infrastructure constraints, aiming to enhance supply chain resilience and global competitiveness.

By combining LSS's focus on continuous improvement with strategic planning's emphasis on risk mitigation and alignment with organizational goals, companies can develop agile and resilient supply chains that drive cost reductions, improve product quality, and increase customer satisfaction.

The case study of AL-DAWLIA, a leading Egyptian manufacturer, demonstrates how aligning Key Performance Indicators (KPIs) with strategic objectives leads to measurable improvements in procurement, operations, and customer satisfaction. Through the application of the DMAIC framework, the study showcases the potential of harmonizing supply chain processes with broader organizational strategies. This research provides valuable insights for enhancing supply chain resilience and establishing a sustainable competitive advantage.

Future research should focus on strategies to sustain improvements, adapt LSS and strategic planning frameworks across industries, and leverage advanced technologies like data analytics and automation to further optimize supply chain performance, especially in developing countries.

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