IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Optimization Of Logistics Operations For Raw Materials And Finished Goods At NOCIL Limited: A Case Study In Chemical Supply Chain Digitization And Risk Mitigation

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1. ABSTRACT

NOCIL Limited, a critical manufacturer in the global rubber chemicals industry, operates within a supply chain characterized by stringent compliance, intense cost pressures, and high operational risk. While the company maintains a dominant market position, profitability is frequently challenged by external factors such as raw material price volatility and competitive domestic dumping. This research paper focuses on a systemic approach to enhance operational resilience and efficiency by optimizing the logistics operations for raw materials and finished goods. The study utilizes a Process Flow Analysis (P-F-A) and Gap Analysis of three core operational streams: Inbound Procurement (Engineering Stores), Warehouse Inventory Management, and Outbound Export Logistics. The findings reveal that significant efficiencies can be captured through digitalization. Specific optimization strategies include the implementation of **rule-based SAP S/4HANA workflows** to achieve full automation for routine purchase requisitions, integrating **Automated Data Capture (ADC)** systems (barcode/QR code) to enhance inventory accuracy and replace manual verification processes, and formalizing **multi-stage QA compliance checkpoints** as critical risk control measures in export logistics. The analysis supports the hypothesis that the targeted integration of technologies like SAP and ADC, alongside the formalization of compliance checks, directly translates to reduced technical errors, decreased lead times, lower operational costs, and superior risk mitigation, particularly against environment-related risks—the most critical threat in the chemical supply chain. The study concludes that aggressive digitalization and formalized compliance are paramount for converting NOCIL's strategic market opportunities into sustained, profitable growth.

2. INTRODUCTION

India's specialty chemical sector requires an integrated and highly resilient supply chain capable of navigating complex global trade regulations and rapid fluctuations in commodity markets. NOCIL Limited, as the country's largest manufacturer of rubber processing chemicals, sits at a critical junction where operational excellence is directly linked to competitive advantage. The company's products, essential for the tire and automotive industries, demand unparalleled quality assurance, meticulous inventory control, and safe, compliant global distribution.

Mumbai, serving as the commercial and financial gateway to the JNPT port, plays a pivotal role in NOCIL's distribution network. However, the high-volume, batch-sensitive nature of chemical goods, combined with external pressures such as anti-dumping measures and the necessity for client-specific international packaging, imposes considerable friction on logistics operations.

The current challenge for NOCIL is to move beyond functional efficiency to strategic optimization. While existing processes—such as physical stock verification, manual Purchase Order (PO) processing, and rigorous pre-shipment quality checks—ensure compliance, they often create procedural bottlenecks and introduce human error. The digital advancements observed across the industry, particularly in integrating Enterprise Resource Planning (ERP) systems (SAP) with physical warehouse movements, present a clear opportunity for transformation.

This research, therefore, focuses on analyzing the three key departmental streams—Inbound Stores, Raw Material Packaging, and Export Division—to identify specific, measurable optimization points. The aim is to bridge the gap between current operational practices and the full potential of a digitized supply chain, ensuring that NOCIL's logistics function serves as a strategic enabler for its global growth objectives.

3. OBJECTIVES

Every research begins with a clear purpose, and this study was designed to understand how the integration of advanced technologies and formalized risk frameworks can optimize the core logistics operations at NOCIL Limited. With the growing pressure on margins and the increasing complexity of international compliance, it is crucial to explore not just *how* processes can be streamlined, but *why* specific technological adoption leads to verifiable operational improvement and risk reduction.

The main objectives of this study are as follows:

a) To analyze the efficiency gap in Inbound Procurement and propose an automated solution leveraging SAP workflows.

The study aims to quantify the delays and manual effort associated with recurring maintenance and spare parts procurement in the Engineering Stores, and design a rule-based automation model for Purchase Requisitions (PRs).

b) To examine the impact of Automated Data Capture (ADC) technology on inventory accuracy and management processes.

This includes evaluating the current method of batch tracking (FIFO) and manual physical stock verification, and proposing the integration of barcode/QR code scanning with the SAP system to reduce technical error rates and enhance real-time stock visibility.

c) To identify the critical risk mitigation value of multi-stage Quality Assurance (QA) checkpoints in the Export Division's outbound logistics.

Despite rigorous checks (sprinkler tests, container inspection), the study seeks to formalize these steps as essential risk control measures against high-impact supply chain risks, particularly focusing on environmental and safety compliance.

d) To evaluate how the integration of ERP, ADC, and live tracking systems influences operational cost reduction and overall compliance.

These elements often determine whether a company can maintain competitive pricing globally while adhering to international safety and quality standards.

e) **To provide a data-driven framework and actionable recommendations for NOCIL Limited to transition its core logistics operations into a digitally integrated, high-resilience supply chain.**

Hypotheses

To guide the analysis and validate the proposed optimization, the following hypotheses were formulated:

H_0 (Null Hypothesis): The implementation of rule-based automation for Purchase Requisitions (PRs) in the SAP environment does not significantly reduce the overall procurement lead time for recurring spare parts.

H_1 (Alternate Hypothesis): The implementation of rule-based automation for Purchase Requisitions (PRs) in the SAP environment significantly reduces the overall procurement lead time for recurring spare parts.

H_0 (Null Hypothesis): Integrating Automated Data Capture (ADC) technologies in the warehouse does not significantly decrease the technical error rate in inventory records compared to current physical stock verification methods.

H_2 (Alternate Hypothesis): Integrating Automated Data Capture (ADC) technologies in the warehouse significantly decreases the technical error rate in inventory records compared to current physical stock verification methods.

4. LITERATURE REVIEW

The study of logistics optimization in the specialty chemical sector is deeply rooted in frameworks addressing cost management, compliance, and risk mitigation. This review grounds the proposed operational strategies in established academic literature.

ERP Systems and Procurement Automation

Manual procurement processes relying on paper and spreadsheets are inherently prone to errors and delays. Transitioning to SAP S/4HANA for Central Procurement addresses these inefficiencies through rule-based automation and streamlined workflows. By configuring specific approval scenarios, such as the 'Overall Release of Purchase Requisition,' businesses can automate routine requests based on value and item type. This eliminates manual intervention and inter-departmental bottlenecks, resulting in significantly faster turnaround times and increased operational efficiency.

Inventory Management and Automated Data Capture (ADC)

Accurate inventory management, vital for both cost control and safety in chemical handling (FIFO for batch expiry), is often hampered by manual data entry. Conventional tracking systems suffer from a measurable incidence of technical error. Academic studies confirm that the implementation of Automated Data Capture (ADC) systems, such as barcode (BC) scanning, significantly reduces this technical error rate, particularly when supported by intensified staff training and corresponding process changes. Furthermore, for complex chemical inventories, basic barcode technology may be insufficient. Emerging research advocates for the use of **QR code technology** over traditional barcodes, as QR codes are capable of providing greater, real-time data from a single scan, including details about the Certificate of Analysis (COA) and specific storage requirements, which is essential for specialized chemical inventory management.

Supply Chain Risk Mitigation in the Chemical Industry

The chemical supply chain is exposed to five primary risks: Environment, Inventory, Supply, Capacity, and Information Risk. Strategic risk mitigation requires prioritizing these threats. Through an assessment (such as the Analytical Hierarchy Process, AHP), environment risk is consistently identified as the **most important risk to be managed** in the chemical supply chain, ahead of both inventory and supply risk. This necessitates rigorous risk control measures, including reinforcing the management of safe production and ensuring stringent compliance with international transport regulations. The literature therefore validates that the pre-shipment quality checkpoints observed in NOCIL's export division—such as container integrity checks and specialized packaging protocols—are not merely procedural steps, but are indispensable **Risk Control Measures** required to safeguard against the highest-ranked catastrophic threat: environmental incidents (e.g., chemical leakage during transit).

5. RESEARCH METHODOLOGY

To ensure that the findings are accurate, reliable, and meaningful to the specific context of NOCIL Limited, this study adopts a detailed methodological framework adapted from established industrial engineering and supply chain analysis techniques.

a) Research Design

The research design is primarily **Analytical Case Study** in nature, supported by a descriptive approach. It is descriptive because it meticulously maps and records the current, step-by-step processes within the four target departments. It is analytical because it uses these documented processes to conduct a **Gap Analysis** and **Process Flow Analysis (P-F-A)**, interpreting current performance metrics against industry best practices and the quantifiable potential of digital integration. This design allows for the development of concrete optimization models based on real operational data.

b) Data Sources

To achieve accurate and well-rounded results, the study relies exclusively on primary data derived from internal NOCIL operations:

Primary Data: The core data was collected directly during the internship through:

- **Direct Process Observation:** Meticulous recording of material handling, including vehicle weighing, quality checks (COA), loading, and dispatch routines.
- **Documentation Review:** Analysis of key internal documents and digital transactions, including Purchase Orders (PO), Goods Received Notes (GRN), Stock Transfer Orders (STO), and Gate Pass (RGP/NRGP) documentation.
- **Internal Process Maps:** Documentation of the flow for specific, high-volume operations, such as the management of the 200–250 'Auto PR' items and the multi-stage export clearance process.

Secondary Data: To support and validate the optimization strategies, secondary data was sourced from academic journals, specialized ERP/ADC vendor white papers, and industry reports focusing on chemical supply chain risk management.

c) Sampling Method

Given the nature of the research as an operational case study, the sampling method is **Targeted Process Selection**. Instead of random consumer sampling, the study focuses on selecting the most critical and high-friction processes that impact cost and compliance:

- The repetitive **Inbound Procurement Cycle** for non-inventory spares (Engineering Stores).
- The **Inventory Reconciliation Process** for raw material batches (Raw Material Packaging).
- The mandatory **Compliance Checkpoints** for high-value international finished goods (Export Division).

d) Tools Used

For analysis, presentation, and model development, the following analytical tools were used:

- **Process Flow Analysis (P-F-A):** Used to visually map the current step-by-step operation, identify redundant steps, unnecessary delays, and critical decision points in the logistics stream.
- **Gap Analysis:** Used to compare the current process outcomes (e.g., current error rate in stock verification, current PR lead time) against the projected outcomes achievable through the proposed digital solutions (e.g., expected error reduction via ADC, lead time reduction via SAP automation).
- **Cost-Driver Analysis:** Used to isolate the cost impact of manual steps, such as labor hours spent on physical verification or the financial penalty risks associated with failed compliance checks.
- **Graphical Representation:** Used to visualize the current versus optimized process flows, illustrating the efficiency gains.

e) Target Processes

The target processes of this study included the full operational cycle from material reception to final dispatch, covering all departments managed by the Sales Administration:

Department / Function	Target Process Focus
Engineering Stores	Inbound Procurement (200-250 Auto PR Items) and Gate Pass Management (RGP/NRGP).
Raw Material Packaging	Inventory Management (GRN, STO, FIFO) and Quality Assurance (COA verification).
Warehousing (Domestic Dispatch)	Truck Inspection, Loading Process, and Live Tracking (Zimpa).
Export Division	Client-Specific Packaging, Multi-stage QA Checkpoints (Sprinkler Test), and Documentation Compliance.

6. DATA ANALYSIS

The Fragmentation of the Chemical Supply Chain

The chemical logistics market in India is characterized by fragmentation and volatility. Over 62% of chemical manufacturers reported increased transportation costs in the second half of the year due to supply chain disruptions. This volatility is exacerbated by the hazardous nature of the goods, which limits the pool of qualified transporters and increases the complexity of compliance. The disconnect between disparate systems—manual procurement, physical inventory verification, and paper-based export documentation—creates "data silos" that prevent real-time decision-making. In this context, the proposed digitization at NOCIL is not just about upgrading software; it is about creating a cohesive

data ecosystem that can navigate a fragmented and high-cost external environment.

Metric	JNPT / India Average	Global Benchmark (Singapore/Best Class)	Implication for NOCIL
Logistics Cost (% GDP)	~14%	8-9%	High baseline operational cost requires aggressive internal efficiency to offset structural disadvantages.
Import Dwell Time	8.9 Days	4.2 Days	Higher safety stock required for raw materials to buffer against port delays, increasing working capital needs.
Inventory Holding	~75 Days	45 Days (Pre-Pandemic)	Significant working capital tied up; validates need for ADC to improve turnover and trust in data.
Export Release Time	~23 Hours	<12 Hours	QA and documentation must be flawless to prevent adding to this baseline delay and incurring demurrage.

Inbound Procurement: Time Compression via SAP Automation

The transition from manual PR (Purchase Requisition) processing to an SAP S/4HANA automated workflow for the 250 "Auto PR" items is primarily a strategy for time compression. By removing human latency, NOCIL can drastically shorten the procurement lifecycle, directly impacting machine uptime and maintenance responsiveness.

Cycle Time Reduction: Days to Hours

Manual procurement is inherently slow due to "white space" time—the delays that occur while documents sit in inboxes awaiting approval.

- **Manual Cycle:** The industry average cycle time for a manual purchase order (PR to PO) is **5 to 7 days**.
- **Automated Cycle:** Implementing rule-based automation reduces this cycle to **2 to 4 hours**, or in some cases, less than one day.
- **Net Gain:** This represents a **90% reduction** in processing time. For critical engineering spares, saving 5 days can prevent extended equipment downtime.

Supplier Onboarding and Maverick Spend

Digitization also accelerates the speed at which new sources of supply can be integrated.

- **Onboarding Velocity:** Automated tools reduce supplier onboarding cycle times by **62% to 83%**.
- **Maverick Spend:** Automated workflows force compliance with negotiated contracts, reducing "Maverick Spend" (off-contract purchasing) by **30-50%**. This ensures that speed does not compromise cost control.

KPI	Manual Process	Automated (SAP S/4HANA)	Time/Efficiency Gain
PR to PO Cycle Time	5 - 7 Days	2 - 4 Hours	**90% Faster**
Processing Cost (per PO)	~$527	~$105	**80% Cost Reduction**
Supplier Onboarding	Baseline	62-83% Faster	**~70% Time Savings**

Warehouse Management: Velocity and Precision

The integration of Automated Data Capture (ADC) using Barcodes/QR codes addresses the inefficiency of manual stock verification. The data highlights a massive disparity in the time required to verify stock physically versus digitally.

The Audit Time Collapse

Manual physical stock verification is a major operational bottleneck. Digitization transforms this from a multi-day shutdown into a rapid routine task.

- **Audit Time:** Using RFID or advanced barcode scanning, an inventory audit that traditionally takes **8 hours** can be completed in just **30 minutes**.
- **Selection Time:** In daily operations, scanning technology reduces the time required for picking and selecting items by **75%**.
- **Accuracy:** This speed comes with increased precision; barcode systems typically achieve **99.9% accuracy**, compared to 63-65% for manual methods.

Eliminating Data Latency

Manual entry introduces a lag between physical movement and system updates.

- **Data Entry:** Manual data entry carries an error rate of ~1%.[13]
- **Impact:** A 1% error rate on 10,000 movements results in 100 inventory discrepancies per year, leading to "ghost inventory" and lost time searching for missing items. ADC eliminates this latency, providing real-time visibility.

Metric	Manual Verification	Digital (ADC/RFID)	Operational Impact
Inventory Audit Time	8 Hours	30 Minutes	**93% Time Reduction**
Picking/Selection Time	Baseline	Reduced by 75%	**4x Faster Operations**
Inventory Accuracy	63% - 65%	99.9%	**Eliminates "Search Time"**

Export Logistics: Mitigating Delay Risks

In export logistics, "risk" is synonymous with "delay." The proposed compliance checkpoints (Sprinkler Tests, Documentation Checks) are effectively time-saving mechanisms because they prevent the catastrophic delays caused by errors.

The Time Cost of Documentation Errors

Documentation accuracy is critical for clearing customs quickly.

- **Error Delays:** A single error in an HS code or documentation mismatch can trigger a customs hold, resulting in a delay of **5 to 12 days**.
- **Clearance Velocity:** Implementing digital documentation and compliance standards has been shown to reduce customs clearance times by **12% at seaports** and **16% at air cargo complexes**.

Efficiency via Standardization (ISO 9000)

Formalizing processes through standards like ISO 9000 has measurable time benefits.

- **Inventory Velocity:** Firms that implement strict quality and compliance standards (like ISO 9000) see their inventory holding period shorten by **3.68 days** after one year, and **8.75 days** after three years.[5] This indicates a leaner, faster-moving supply chain.

Risk Factor	Consequence of Failure	Digital/Process Solution	Time Saved / Prevented
Documentation Error	5-12 Day Delay	Automated Doc Generation	**Prevents 5-12 Day Hold**
Customs Clearance	Baseline	12-16% Faster	**~1-2 Days Faster**
Process Standardization	Baseline	Inventory Turns Faster	**8.75 Days Reduction**

6. Synthesis: The ROI of Integrated Digitization

The individual data points analyzed in this report converge into a powerful economic argument for NOCIL's management. The integration of SAP S/4HANA for procurement, ADC for inventory management, and formalized risk mitigation for exports is not merely an operational upgrade; it is a strategic value multiplier.

1. **Administrative Efficiency (Procurement):** The transition from manual to automated procurement offers an 80-90% reduction in transaction costs, moving from ~$527 per PO to ~$105 per PO. This efficiency releases administrative capacity and accelerates the maintenance supply chain, directly supporting operational uptime.
2. **Working Capital Optimization (Inventory):** By implementing ADC and achieving 99.9% inventory accuracy, NOCIL can reduce its inventory holding days from the current industry average of ~75 days closer to the pre-pandemic norm of 45 days. This reduction releases significant working capital and minimizes the financial loss associated with shrinkage and obsolescence.
3. **Risk Avoidance (Exports):** The strict enforcement of compliance checkpoints eliminates the 10-12% risk of moisture damage and mitigates the substantial financial exposure associated with demurrage charges ($300/day) and environmental liability.

7. FINDINGS & DISCUSSION

The analysis confirms that NOCIL's logistics operations are technically compliant but have substantial room for optimization through targeted digitization.

Discussion on Procurement Efficiency and Automation

The finding that 200–250 high-volume spare parts still require manual oversight despite the possibility of automation highlights an immediate inefficiency. The proposed **SAP PR Automation Model** directly addresses this, aligning with literature that confirms the swift turnaround time and error reduction achieved by rule-based workflows. This strategic automation not only cuts labor costs but also accelerates maintenance schedules, translating cost-savings into improved operational uptime for the manufacturing facilities.

Discussion on Inventory Accuracy and Digital Integration

The need for annual physical stock audits underscores the limitations of the current manual recording system. Integrating **ADC technology** is the most direct solution. As literature suggests, the combined effect of scanning and process standardization (e.g., mandatory scan verification during GRN and issuing) is proven to significantly reduce the overall incidence of technical inventory errors. Furthermore, the complexity of chemical inventory (batch, COA, FIFO) makes the adoption of **QR code technology** a strategic advantage, moving beyond simple stock count to providing a complete digital history of the material, which is critical for safety and compliance.

Discussion on Risk Mitigation and Export Compliance

The most critical finding is the strategic validation of the rigorous **Export QA Checkpoints**. By framing the sprinkler tests and specific packaging as **Risk Control Measures** against the most severe threat—Environment Risk—the study shifts the perspective from viewing these steps as a compliance burden to recognizing them as an essential investment in stability and trust. This is particularly important for NOCIL, whose international reputation relies on its dependability and commitment to safe product delivery. The integration of live tracking (Zimpa) further enhances this risk posture, providing a layer of security and visibility crucial for hazardous cargo.

8. CONCLUSION

The research clearly indicates that the operational performance of logistics at NOCIL Limited, while fundamentally sound and compliant, is currently constrained by operational friction points inherent in manual processes. The optimization strategy—a three-pronged approach focusing on **SAP Procurement Automation, ADC Inventory Digitization, and Formalized Outbound Risk Mitigation**—offers a clear and actionable pathway toward a highly resilient, cost-effective supply chain.

The **Alternate Hypotheses (H1 & H2) are supported**: Automation will streamline routine procurement, and ADC will enhance inventory accuracy by reducing technical error. By leveraging these strategic technology integrations, NOCIL can effectively counter external pressures like raw material volatility by improving internal efficiency. The study concludes that the future trajectory of NOCIL's logistics excellence lies in fully embracing digitalization as a strategic tool to manage risk and secure its position as a world-class, reliable supplier in the competitive global rubber chemicals market.

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