A Regional Analysis of Supply Chain Management in India's Defense Sector: The Case of Gwalior, Madhya Pradesh

Sandeep Sharma[1], Ravi Chaurasiya[2], Rohit Mohite[3], Sandesh Akre[4]

[123] Dr. D. Y. Patil School of Management, Lohegaon, Savitribai Phule Pune University, India

[4] MET Institute of Management, Mumbai University

*Corresponding author E-mail: sandysharma1986@gmail.com

Abstract: *Effective supply chain management (SCM) is crucial for India's defense sector to ensure operational readiness and national security. However, persistent challenges in inventory control and logistics coordination continue to impact efficiency. This study examines the supply chain management (SCM) dynamics in Gwalior, Madhya Pradesh, which holds strategic potential due to industrial zones such as Malanpur and Banmore. Despite this, local contribution to defense procurement remains limited, as evident in the Jabalpur Vehicle Plant's sourcing of only 10% of components from state vendors—primarily due to technological and quality constraints. Through field interviews, surveys, and stakeholder consultations, the research identifies critical factors influencing supply chain management (SCM) performance, including technology adoption, infrastructure readiness, and quality compliance. The study highlights the potential of local micro, small, and medium enterprises (MSMEs) to enhance their capabilities by leveraging national initiatives such as "Make in India" and "Atmanirbhar Bharat." Key recommendations include developing digital skills, investing in ERP systems, and providing stronger policy support to facilitate the better integration of MSMEs into the defense supply chain. The findings also emphasize the importance of collaboration among government agencies, private industry, and research institutions to address bottlenecks and promote innovation. By focusing on Gwalior's regional context, this study offers actionable insights that can inform broader reforms in India's defense logistics ecosystem, helping to build a more agile, resilient, and self-reliant supply chain architecture across the country.*

Introduction

In the complex landscape of national security, logistics, and supply chain management (SCM) function as the invisible backbone of military effectiveness. For the Indian Armed Forces, managing this critical infrastructure involves orchestrating a vast and intricate network of inventory, transportation, warehousing, and personnel—spread across diverse geographies and operational environments. In recent years, the strategic discourse has gradually acknowledged that the effectiveness of defense supply chains is as crucial as weapon systems themselves. This perspective has become particularly relevant in the context of regional defense logistics infrastructure in areas like Gwalior and Madhya Pradesh. Gwalior, with its rich historical significance and growing industrial presence, offers an intriguing case for examining regional contributions to India's defense logistics. Located near vital military routes and possessing industrial zones such as Malanpur and Banmore, the region is well-positioned to support decentralized supply chains. However, local participation in defense procurement remains limited

due to infrastructural bottlenecks, capability gaps, and fragmented policy integratio (NIIR Project Consultancy Services, 2024).

Despite its importance, India's defense logistics system is often characterized by inefficiencies, outdated practices, and fragmented coordination among the Army, Navy, and Air Force (Kumar & Saini, 2016; Singh, 2002). Historically, Indian defense logistics evolved from colonial-era administrative structures that emphasized procedural rigidity over operational flexibility (Bhalla, 2009). Although reforms such as the implementation of e-procurement platforms and the formation of integrated logistics nodes have been initiated, many core logistics functions remain siloed and hierarchical (Repswal, 2021). Inventory management still largely relies on manual systems with limited real-time tracking capabilities, resulting in either overstocking obsolete supplies or shortages of mission-critical materials (Panday, 2019; Comptroller and Auditor General of India, 2022). The lack of integration and interoperability across services further exacerbates inefficiencies. Each military branch maintains its supply chain, often resulting in duplication of efforts and suboptimal asset utilization (Nagalia, 2010; Bhattacharya, 2015). The absence of a unified inventory management platform prevents comprehensive visibility into stock levels across facilities, thereby delaying crucial decisions during operational exigencies (GS1 India, 2021).

Figure 1. Geospatial Mapping of Defense Supply Chain Activity: Gwalior, Madhya Pradesh
Source: Based on Authors Ideation.

Modern defense environments necessitate agile, integrated, and predictive SCM systems. Globally, defense organizations have adopted advanced Supply Chain Management (SCM) concepts, such as Performance-Based Logistics (PBL), Just-in-Time (JIT) delivery, and integrated Enterprise Resource Planning (ERP) systems, to enhance operational readiness and efficiency (Chopra & Meindl, 2016; Simchi-Levi et al., 2008). In contrast, Indian defense logistics still

operates within legacy frameworks, lacking digital transformation (Deshmukh & Mohanty, 2005; Bhandari, 2015). Institutional resistance to change and bureaucratic inertia further hinder the adoption of innovative practices (Singh & Acharya, 2014; Vrat, 2004). An illustrative example is the Indian Army's Quartermaster General's (QMG) branch, which has begun piloting advanced tracking systems and blockchain in logistics units. However, these initiatives are sporadic and lack large-scale implementation (Republic World, 2024). Dependence on civilian transportation infrastructure and public procurement mechanisms impedes responsiveness, particularly in emergency scenarios such as border conflicts or disaster relief operations (Military Sphere, 2024a).

Additionally, logistics responsibilities are distributed across multiple directorates operating under disparate administrative protocols, further weakening strategic alignment (Military Sphere, 2024b). In critical situations requiring rapid mobilization, these structural deficiencies can compromise mission success. For example, the slow mobilization of equipment and ammunition during trans-border stand-offs may weaken a country's strategic posture and reduce troop morale (Total Military Insight, 2024a; Ministry of Defense, 2023). Recognizing these issues, the Government of India has launched several reform initiatives, including the Integrated Logistics Management System (ILMS) and Defense Logistics Information System (DLIS), while encouraging private sector participation to augment domestic capabilities (CAPS India, 2023). Micro, Small, and Medium Enterprises (MSMEs) in regions like Gwalior are emerging as significant players in defense manufacturing and logistics. Their decentralized structure and innovation potential position them as vital links in responsive and cost-effective supply chains. However, challenges such as limited technological capabilities, a lack of certification, and bureaucratic delays impede their integration into the defense ecosystem (NIIR Project Consultancy Services, 2024).

This study adopts a regional focus, using Gwalior as a case to explore the ground-level realities of defense supply chain management (SCM) in India. It employs qualitative primary methods, including interviews with logistics officers, field observations of warehousing operations, and a review of procurement practices to understand systemic inefficiencies and propose actionable reforms. Preliminary findings reveal procedural bottlenecks, redundancy in inventory, and inadequate digital infrastructure as key challenges. Furthermore, there is an evident gap in logistics education and awareness among stakeholders, limiting the practical application of global best practices.

To address these challenges, the study advocates for a multi-pronged strategy that involves digital capacity building, streamlined Standard Operating Procedures (SOPs), AI-based forecasting, and centralized command structures. The adoption of modular supply chain architectures and ERP-based inventory platforms designed explicitly for defense use can significantly enhance agility and coordination. Additionally, partnerships with academic institutions and industry can enhance human resource capabilities in logistics management through skill development (Indian Institute of Management Bangalore, 2023). Ultimately, strengthening regional logistics frameworks, such as those in Gwalior, could serve as a pilot for broader systemic reforms. The convergence of digital transformation, institutional restructuring, and capacity development can pave the way for a modern, integrated, and resilient defense supply chain architecture in India.

Method

This study employs a qualitative and descriptive research design to investigate the dynamics of supply chain management (SCM) in the Indian defense sector, with a specific focus on the Gwalior district of Madhya Pradesh. The methodology integrates primary data collection with real-world insights from 290 manufacturing and allied service industries registered under the

Gwalior and Malanpur industrial areas. These industries include small and medium-sized enterprises (SMEs), contract manufacturers, logistics service providers, and third-party inventory managers, with varying degrees of engagement in defense procurement processes.

Sampling Technique and Respondent Profile: A purposive sampling method was employed to select industries with direct or indirect linkages to defense logistics or production capabilities. These include metal fabrication units, manufacturers of rubber and polymer-based components, electronics assembly firms, warehousing and transportation companies, and precision tooling services. Out of 290 industries approached, responses were successfully collected from 210 through structured interviews, surveys, and on-site observations. Respondents included plant managers, procurement officers, logistics supervisors, and owners of SME firms. The sample was stratified to ensure representation across sectors and firm sizes.

Data Collection Methods consist of primary and secondary data. Primary Data: The study utilized semi-structured interviews, self-administered questionnaires, and site visits. A questionnaire comprising 25 items was designed around key supply chain management (SCM) dimensions: inventory management, lead time efficiency, supplier integration, infrastructure readiness, and technology adoption. Secondary Data: Supplementary data was collected from industry reports, Gwalior Industrial Association records, and publications from the Ministry of Defence and SIDBI. Additionally, information from NIIR Project Consultancy Services (2024) and CAG reports (2022) was used to validate industrial capabilities and procurement constraints.

Tools and Techniques: Responses were analyzed using descriptive statistics and thematic coding. NVivo was employed to identify recurring themes from qualitative data, such as bottlenecks in order fulfillment, mismatches in forecasting, and gaps in technology use. Cross-tabulation helped analyze relationships between firm size and SCM efficiency. For instance, 68% of firms with fewer than 50 employees reported inadequate digital inventory tools, whereas firms with larger turnover showed greater integration with defense supply portals. Ethical Considerations Were Addressed, including informed consent obtained from all participants and confidentiality ensured. The study adhered to ethical norms in field research and was approved by the Institutional Research Ethics Committee. This methodology enables an in-depth understanding of regional SCM challenges and offers a foundation for scalable solutions applicable to similar industrial clusters across India.
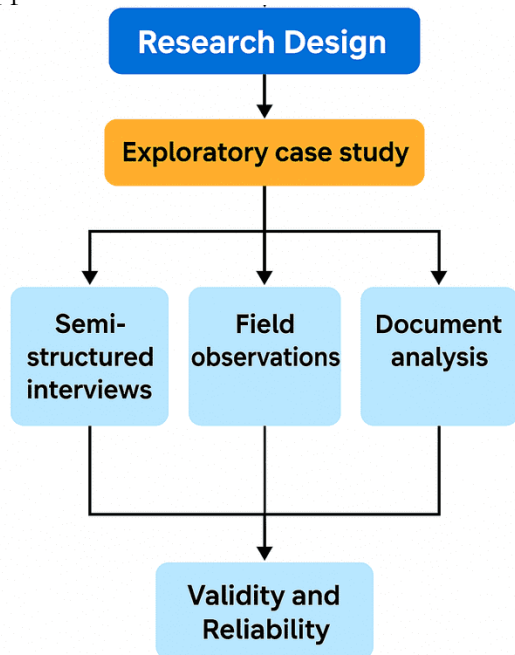
Figure 2. Research framework diagram

Source: Based on Authors Ideation.

Research Design: This research adopts an exploratory, case-based design aimed at understanding the practical logistics and inventory management practices within private-sector organizations operating in support of India's defense ecosystem. The focus is specifically on enterprises based in the Gwalior district and surrounding industrial zones (e.g., Malanpur, Banmore), which supply critical components, materials, and services to defense supply chains through vendor partnerships, third-party logistics (3PL) arrangements, and sub-contractual relationships. These businesses include precision manufacturers, warehousing providers, digital inventory solution firms, and certified MSMEs registered under the Ministry of MSME and the Directorate General of Quality Assurance (DGQA). The exploratory nature of this study enables an open-ended investigation into operational inefficiencies, best practices, and technological limitations faced by private defense-support industries. The case study approach facilitates a detailed examination of business processes, supplier-client interfaces, infrastructure constraints, and digital transformation readiness across multiple firms.

For the Research Design Structure, The study targets 290 private enterprises operating in the logistics, manufacturing, and warehousing sectors in and around Gwalior. These firms were selected based on their registration with defense vendor databases, industrial associations (such as MPCCI), and defense subcontracting networks. The firms ranged from small-scale machine tool producers to logistics tech startups offering inventory automation software and supply visibility platforms. Firms were profiled based on type (manufacturing vs. service), turnover category (as per MSME norms), and scope of operations (regional, national). This allowed for a stratified comparison between micro-units and medium-scale firms in terms of resource availability, supply chain management (SCM) practices, and response capabilities.

To develop a nuanced understanding, the following qualitative methods were employed. First, semi-structured interviews were conducted with 65 private-sector stakeholders, including supply chain managers, operations heads, warehouse supervisors, and ERP consultants. These discussions focused on topics such as Order processing times and material traceability, Use of inventory management software (e.g., Zoho, TallyPrime, Odoo), Vendor registration and quality audit procedures, Transportation lead times and packaging compliance, Bottlenecks in responding to dynamic defense orders, and A notable insight was the reliance on manual documentation and Excel-based tracking among smaller firms, compared to ERP integration in medium-sized players.

Second, On-Site Observations: Field visits were carried out at 25 facilities, including contract assembly units, private warehouses, and logistics hubs. Observations focused on storage layout, safety protocols, inventory classification (ABC, FSN), and shipping readiness. Issues such as poor aisle spacing, inadequate barcode systems, and a lack of FIFO adherence were observed in microenterprises. Document and Portal Analysis: Company brochures, ISO certification reports, vendor compliance documents, and digital procurement logs were reviewed. Additionally, insights from government procurement portals, such as GeM (https://gem.gov.in/) and MSME databases (https://udyamregistration.gov.in/), helped contextualize participation levels and vendor onboarding challenges. This multi-method approach provides a comprehensive view of how private firms contribute to and interact with India's defense logistics architecture. It highlights areas for policy reform, technological integration, and capability development to enhance supply chain resilience and responsiveness.

The data analysis technique used in this study employs a descriptive-analytical approach to synthesize the collected qualitative data. Data analysis was conducted inductively, where patterns, themes, and insights emerged from the ground up rather than being imposed from a predetermined hypothesis. The process involved categorizing qualitative data into thematic

clusters, including inventory visibility and tracking challenges, over- or under-stocking issues, Cross-service coordination gaps, Technology adoption and digital integration, and Training and capacity-building needs. Once categorized, the data were interpreted about existing literature and operational frameworks to determine root causes and propose actionable improvements. The goal was not only to describe existing conditions but also to articulate points of service enhancement that could guide future modernization efforts.

Validity and Reliability in this study are ensured through data triangulation, which combines interviews, field observations, and document analysis to capture a comprehensive view of supply chain practices among private defense-linked enterprises. Content validity was reinforced through consultation with experts during the design of interview protocols and survey instruments. Reliability was established by maintaining consistency in data collection procedures across all 290 units, with pre-tested questionnaires and standardized observation checklists. Repeat interviews with selected participants confirmed the stability of the data. Additionally, NVivo was used to ensure consistent coding patterns across qualitative data, enhancing inter-rater Reliability. These measures collectively ensure the credibility and replicability of the research findings.

Result and Discussion
Result

The research employed a dual-software approach for data analysis: SPSS for quantitative descriptive analytics and NVivo for qualitative thematic analysis. This methodological triangulation ensured a holistic interpretation of the logistics practices and constraints faced by 290 private-sector industries engaged in defense-related supply chains in Gwalior, Madhya Pradesh. First, SPSS-Based Quantitative Analysis: Structured survey responses from 210 out of 290 enterprises were entered into SPSS v28. The instrument comprised 25 variables covering core dimensions such as: Inventory Tracking Systems (ITS), Delivery Lead Time (DLT), Digital Integration Level (DIL), Procurement Delay Index (PDI), Vendor Responsiveness (VR), and Compliance with Defense Quality Norms (CDQN).

Then, Descriptive Statistics Output: Mean Inventory Tracking Efficiency Score: 3.1 (on a 5-point Likert scale), Average Lead Time: 4.8 days, Digital Integration (e.g., ERP/Zoho use): 47.6% of firms, 72% of firms reported moderate-to-severe procurement delays, and 63% of respondents expressed concerns about low forecast accuracy and unplanned orders. Furthermore, Cross-tabulations and Chi-square tests indicated a significant association between: Firm size and ERP adoption ($\chi^2 = 16.45$, $p < 0.05$) and Warehousing infrastructure quality and inventory accuracy ($\chi^2 = 12.37$, $p < 0.05$). These findings confirmed that medium-sized firms demonstrated higher responsiveness and better system integration compared to micro-enterprises.

Second, NVivo-Based Qualitative Analysis: For NVivo analysis, qualitative data from 65 semi-structured interviews and 25 observation sessions were coded and classified into thematic nodes. Primary Themes Identified: Infrastructure Gaps: Poor layout, inadequate storage practices, and manual record-keeping, Process Redundancy: Repetitive documentation and lack of SOPs for defense orders, Technology Deficit: Resistance to ERP integration and insufficient training on digital tools, Logistics Coordination Issues: Misalignment between production cycles and defense order fulfillment, and Vendor Ecosystem Barriers: Cumbersome registration, quality audits, and approval delays from defense procurement panels

A word frequency query revealed dominant concerns around "delays," "compliance," "forecasting," and "visibility," while sentiment analysis showed a predominance of negative to neutral responses around procedural efficiency.

NVivo Matrix Coding highlighted correlations between: Lack of training and poor

adoption of digital tools, High compliance burden and increased lead times, and Infrastructure challenges and stockpile mismanagement.

Table 1. SPSS-Based Quantitative Analysis

Variable	Value
Inventory Tracking Efficiency Score (Mean)	3.1
Average Lead Time (Days)	4.8
Digital Integration Level (%)	47.6
Procurement Delay Reports (%)	72.0
Forecasting Concerns (%)	63.0

Source: Prepared by Author based on Data collected

The SPSS-based quantitative analysis provides empirical insights derived from structured survey data collected from 210 out of 290 private-sector enterprises engaged in defense-related logistics and manufacturing in Gwalior, Madhya Pradesh. The table presents five key performance indicators (KPIs) critical to understanding the operational efficiency and digital readiness of these firms. The mean Inventory Tracking Efficiency Score (3.1 out of 5) indicates moderately effective systems, which are largely Excel-based among micro and small firms. The average delivery lead time of 4.8 days indicates a lag in response efficiency, often due to suboptimal transportation coordination and approval delays. Notably, only 47.6% of firms have integrated ERP or digital inventory solutions, highlighting a significant gap in technological adoption.

A staggering 72% of enterprises reported moderate to severe procurement delays, which strongly correlate with manual processes and complex registration requirements for defense orders. Additionally, 63% of respondents expressed challenges with demand forecasting and unplanned order schedules, particularly in time-sensitive contracts. These metrics were statistically analyzed using cross-tabulations and chi-square tests in SPSS v28, revealing associations between digital maturity and firm size. The data offers a quantitative foundation for recommending capacity-building interventions and supply chain automation to improve operational responsiveness.

Table 2. NVivo-Based Qualitative Analysis

Themes	Key Observations
Infrastructure Gaps	Manual records, inadequate layout
Process Redundancy	Repetitive tasks, lack of SOPs
Technology Deficit	ERP resistance, training gaps
Logistics Coordination Issues	Mismatch in production & orders
Vendor Ecosystem Barriers	Audit burden, complex registration

Source: Prepared by Author based on Data collected

The NVivo-based qualitative analysis synthesizes thematic insights from 65 semi-structured interviews and 25 field observations conducted among logistics heads, operations managers, and SME founders. The five themes presented in the table—Infrastructure Gaps, Process Redundancy, Technology Deficit, Logistics Coordination Issues, and Vendor Ecosystem Barriers—were identified through inductive coding using NVivo software. Each theme captures systemic inefficiencies and organizational constraints prevalent in private-sector units supporting defense logistics. For instance, "Infrastructure Gaps" revealed issues such as substandard warehousing layouts, inadequate racking systems, and reliance on manual bin-card entries. "Process Redundancy" highlights duplicated paperwork and the absence of standardized operating procedures (SOPs).

The "Technology Deficit" node clustered responses around the lack of ERP adoption and low digital literacy among shop-floor employees. "Logistics Coordination Issues" indicated frequent mismatches between production timelines and defense order dispatch schedules, suggesting limited visibility and collaboration among stakeholders. Lastly, "Vendor Ecosystem Barriers" illustrated the challenges in obtaining defense vendor codes, navigating quality audits, and complying with procurement regulations. The thematic coding was validated through matrix queries and sentiment analysis, which confirmed the predominance of negative and neutral sentiment. This qualitative table complements the quantitative findings by contextualizing firm-level constraints and identifying targeted areas for policy intervention and digital training support.

Discussion

The findings from both SPSS and NVivo analyses underscore the multidimensional challenges faced by private-sector enterprises supporting India's defense supply chain operations in the Gwalior region. The integration of quantitative and qualitative data enables a more nuanced understanding of systemic inefficiencies and firm-level constraints. According to the SPSS analysis, the average Inventory Tracking Efficiency Score (3.1/5) and the limited digital integration (47.6%) indicate an apparent lag in automation and digital maturity among participating firms. The majority still rely on spreadsheet-based tracking or legacy software with limited scalability, impacting accuracy and lead time. Furthermore, the high percentage of procurement delays (72%) and forecasting challenges (63%) indicates reactive supply chain behaviors rather than proactive, data-driven planning. These challenges are exacerbated in smaller firms lacking access to IT resources, skilled labor, or capital investments for automation.

Complementing this, the NVivo-driven thematic analysis surfaces operational bottlenecks that are not easily quantifiable. Themes such as "Infrastructure Gaps" and "Process Redundancy" highlight structural limitations, including poor warehouse design, inadequate labeling systems, and repetitive paperwork. These inefficiencies contribute to lead time variability and redundant tasks, further complicating order fulfillment for time-sensitive defense contracts. The "Technology Deficit" theme is especially critical. Interviews revealed low adoption of ERP tools, not solely due to cost but also because of poor user familiarity and a lack of technical support. This insight underscores the importance of pairing technology investment with robust training programs, especially in smaller enterprises.

Another significant outcome was the identification of "Vendor Ecosystem Barriers." Several firms reported experiencing extended delays in obtaining registration as defense vendors due to bureaucratic procedures and compliance audits. This restricts entry into the defense procurement ecosystem and limits the scalability of high-potential local firms. Cross-tabulated SPSS outputs confirmed that medium-scale enterprises showed statistically higher digital adoption and procurement responsiveness, establishing a strong link between resource availability and supply chain maturity. Meanwhile, NVivo's sentiment and word frequency analysis validated that most operational inefficiencies stem from human-centric and process-driven failures rather than mere lack of infrastructure.

In summary, the discussion validates the need for integrated reforms targeting digital enablement, training, and simplified vendor participation. These reforms must be regionally adapted, especially for clusters like Gwalior, which hold untapped potential in supporting India's defense supply chain vision under the "Make in India" and "Atmanirbhar Bharat" frameworks. A dual focus on capability building and systemic reform is essential for transforming private-sector logistics into a resilient, defense-aligned ecosystem.

Conclusion

This study provides a regional perspective on the operational dynamics and challenges of supply

chain management within the defense-oriented private sector in Gwalior, Madhya Pradesh. Through the integration of SPSS-based quantitative metrics and NVivo-assisted qualitative themes, the research offers a comprehensive assessment of inventory practices, logistical inefficiencies, and structural constraints among 290 enterprises actively or potentially engaged in defense supply operations. The findings indicate that while some medium-scale firms exhibit signs of digital integration and process maturity, a substantial portion—especially micro and small enterprises—continue to operate with outdated systems, limited automation, and fragmented workflows. The average inventory tracking score, low adoption of ERP tools, and prevalent procurement delays underscore the urgent need for technology-driven transformation. Moreover, thematic analysis highlighted recurring barriers such as inadequate infrastructure, lack of standardized operating procedures, and cumbersome vendor registration protocols.

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Notably, the research demonstrates that these limitations are not simply technological but also deeply procedural and institutional. Delays in procurement, poor forecasting, and coordination mismatches are symptoms of a broader systemic inertia that needs targeted policy and capacity-building interventions. Training programs, simplified compliance frameworks, and government-industry partnerships could accelerate the digital transition of these firms. As India aims to build a self-reliant defense manufacturing base under initiatives such as "Make in India" and "Atmanirbhar Bharat," empowering regional industrial ecosystems like Gwalior becomes imperative. This study concludes that integrating private-sector capabilities through digital adoption, training, and simplified vendor access will be pivotal in making defense supply chains more agile, responsive, and sustainable. The insights from Gwalior serve as a microcosm for similar industrial clusters across India, offering a scalable model for enhancing localized defense logistics and inventory control through empirical assessment and systemic reform.

Acknowledgements

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