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Inventory Control Techniques Management Bharat Heavy Electricals Limited (BHEL)

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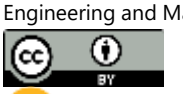

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Abstract

This study investigates the efficiency of inventory control practices in the project logistics operations of Bharat Heavy Electricals Limited (BHEL), Tiruchirappalli — India's premier boiler manufacturer. As an Engineering, Procurement, and Construction (EPC) entity, BHEL manages a vast array of high-value components, raw materials, and sub-assemblies essential for uninterrupted project execution. The study evaluates traditional and modern inventory models — including ABC Analysis, Economic Order Quantity (EOQ), Safety Stock, VED, and SAP-integrated ERP systems — to determine their impact on reducing holding costs and preventing stockouts. A structured questionnaire survey was administered to 110 employees across Production, Stores, Purchase, Logistics, and Quality departments. Data were analysed using One-Way ANOVA, Chi-Square tests, and Spearman's Rank Correlation. Findings indicate that supply delays (34.5%) and poor tracking (24.5%) are the dominant operational challenges, while 74.5% of respondents expressed overall satisfaction with the current inventory management system.

Keywords: *Inventory Management, ABC Analysis, ERP Systems, Safety Stock, Supply Chain, BHEL, Project Logistics, EOQ, VED Analysis, Manufacturing Operations*

1. Introduction

Inventory management is a cornerstone of operational efficiency in large-scale manufacturing enterprises. In capital-intensive sectors such as power plant manufacturing, the consequences of poor inventory control — including production stoppages, cost overruns, and project delays — can be severe and far-reaching. Bharat Heavy Electricals Limited (BHEL), established in 1964 and headquartered in New Delhi, stands as India's largest engineering and manufacturing enterprise in the energy and infrastructure sectors.

BHEL Trichy, one of the organisation's most significant manufacturing units, specialises in the production of high-pressure boilers, steam generators, and seamless steel tubes for thermal and nuclear power plants. The unit operates within an EPC framework, where materials management directly influences project timelines and client satisfaction. With a pan-India presence spanning 16 manufacturing units and over 140 project sites, BHEL regularly manages thousands of high-value components, specialised sub-assemblies, and raw materials across complex, multi-stage supply chains.

The present study focuses specifically on the Materials Management (MM) and Project Logistics divisions of BHEL Trichy. It examines how inventory control techniques — including ABC Analysis, EOQ, Just-in-Time (JIT), and SAP-ERP modules — are deployed in practice, and how employee perceptions of these systems inform their effectiveness. Given that inventory often constitutes the largest component of working capital in EPC organisations, understanding the gap between adopted methodologies and operational outcomes is both academically significant and practically relevant.

2. Literature Review

The academic literature on inventory and supply chain management provides a rich theoretical foundation for the present study. Chopra and Meindl (2016) articulate the strategic, planning, and operational dimensions of supply chain management, arguing that alignment between supply chain design and business strategy is critical for performance optimisation. Their framework serves as the overarching lens for evaluating BHEL's inventory practices.

Christopher (2011) emphasises customer-centric supply chains and the importance of agility and flexibility, advocating for lean supply chain concepts and integrated warehouse optimisation. Simchi-Levi et al. (2008) contribute quantitative decision-making models — including linear programming and network modelling — that are directly applicable to the procurement and scheduling challenges encountered at BHEL Trichy.

Gunasekaran and Ngai (2004) demonstrate that real-time data sharing and ERP systems are critical for coordination across supply chain partners, a finding that resonates strongly with BHEL's adoption of SAP-integrated inventory tracking. Beamon (1998) calls for a holistic approach to supply chain optimisation, balancing cost, service, and flexibility — a balance that BHEL must strike between carrying costs and safety stock levels.

Tang (2006) highlights risk management frameworks for supply chain disruptions, recommending risk pooling and strategic sourcing as resilience strategies — directly relevant to BHEL's exposure to raw material price fluctuations and supplier reliability issues. Ivanov et al. (2017) further argue that Industry 4.0 technologies, including IoT and predictive analytics, are transformative for supply chain agility, suggesting a clear roadmap for BHEL's digital future. Kumar and Jain (2022) and Zhang et al. (2024) extend this discourse into green supplier selection and multi-objective logistics optimisation, offering forward-looking frameworks for sustainable inventory management.

3. Conceptual Framework / Research Model

The conceptual framework adopted in this study positions inventory control as the central mediating mechanism between input conditions (supply, demand, and technological infrastructure) and desired organisational outcomes (operational efficiency and cost reduction). The model draws on the Input-Process-Output (IPO) paradigm and is adapted to the EPC manufacturing context of BHEL Trichy.

Input Variables	Inventory Control Mechanisms	Output Variables
Raw material availability Supplier lead times Demand variability ERP / SAP systems	ABC Analysis EOQ Model Safety Stock JIT VED / FSN Analysis	Reduced holding costs Production continuity Operational efficiency Customer satisfaction

The framework posits that the effectiveness of inventory control mechanisms is moderated by two key contextual factors: (1) employee competency in using digital systems, and (2) the reliability of external suppliers. These moderators reflect the dual human-technological nature of inventory management in large public-sector enterprises.

4. Research Methodology

4.1 Research Design

This study adopts a descriptive research design, which is appropriate for systematically describing the characteristics and practices of inventory management at BHEL Trichy. Both primary and secondary data sources were employed.

4.2 Population and Sampling

The target population comprised employees across the Production, Stores, Purchase, Logistics, and Quality departments of BHEL Trichy. Using simple random probability sampling from a pool of 700 workers, a sample of 110 respondents was selected. The sample includes male (60.9%) and female (39.1%) employees, with the largest age cohort in the 26–30 range (30.0%) and the majority holding 1–5 years of work experience (30.0%).

4.3 Data Collection

Primary data were collected via a structured, 25-item questionnaire divided into five sections: demographic profile, inventory processes and techniques, technology and cost management, challenges and feedback, and suggestions and recommendations. Secondary data were drawn from BHEL company reports, industry journals, and published academic literature.

4.4 Statistical Tools

Three inferential statistical techniques were employed: (1) One-Way ANOVA to examine differences in satisfaction scores across departments and experience levels; (2) Pearson Chi-Square tests to assess associations between categorical demographic variables and inventory practices; and (3) Spearman's Rank-Order Correlation to identify the strength and direction of relationships between key inventory management variables. All analyses were conducted at a 5% significance level ($p < 0.05$).

5. Data Analysis and Results

5.1 Descriptive Findings — Survey Data

Table 1 summarises the key findings from the 25-item survey instrument, presenting the most frequently reported responses and their percentage distributions across the 110 respondents.

Table 1: Survey Findings Summary

Survey Item	Response A	Response B	Finding
Proper Inventory Records Maintained	Yes: 82	No: 28	74.5% Yes
Inventory Check Frequency	Weekly: 40	Daily: 20	36.4% Weekly
Commonly Used Technique	ABC: 38	EOQ: 28	34.5% ABC
Safety Stock for Critica Materials	Yes: 75	No: 35	68.2% Yes
Inventory Shortage Affects Production	S.Agree: 44	Agree: 36	72.7% Agree
Computerized Inventory Syster Used	Yes: 85	No: 25	77.3% Yes
ERP Improves Tracking	S.Agree: 50	Agree: 32	74.6% Agree
Major Inventory Problem	Delay: 38	Poor Track: 27	34.5% Delays
Top Improvement Suggestion	Automation: 32	Better ERP: 28	29.1% Auto
Overall Satisfaction Level	Good: 44	V.Good: 38	74.5% Positive

The data reveal several critical operational patterns. ABC Analysis is the dominant inventory control technique (34.5%), followed by EOQ (25.5%) and Safety Stock (21.8%). A majority of 77.3% confirm BHEL uses computerised inventory systems, and 74.6% agree that ERP systems improve tracking accuracy.

5.2 One-Way ANOVA Results

Table 2 presents the ANOVA results for overall inventory satisfaction disaggregated by department.

Table 2: One-Way ANOVA — Satisfaction by Department

Group	N	Mean	Std Dev	Std Error	95% CI Low	95% CI Up	Sig.
Logistics	15	2.933	0.961	0.248	2.400	3.467	
Production	23	2.870	0.757	0.158	2.543	3.196	0.453
Purchase	24	2.875	0.741	0.151	2.562	3.188	
Quality	32	2.938	0.840	0.149	2.635	3.240	

Group	N	Mean	Std Dev	Std Error	95% CI Low	95% CI Up	Sig.
Stores	16	3.313	0.704	0.176	2.937	3.688	
Total	110	2.964	0.801	0.076	2.813	3.115	

The ANOVA yielded F = 0.924 (p = 0.453) for the department analysis and F = 0.734 (p = 0.534) for the work experience analysis, both above the 0.05 threshold. The null hypotheses are accepted in both cases, indicating no statistically significant variation in satisfaction across departments or experience levels.

5.3 Chi-Square Test Results

Table 3 presents the results of five Chi-Square tests examining associations between demographic variables and inventory practices.

Table 3: Chi-Square Test Results

Test	Chi-Square	Df	Sig.
Gender × Inventory Records	3.246	1	0.072 (NS)
Department × Safety Stock	2.847	4	0.584 (NS)
Age Group × ERP System Usage	0.498	3	0.919 (NS)
Work Experience × Record Updating	3.789	3	0.285 (NS)
Gender × Training Effectiveness	0.227	1	0.634 (NS)

All five Chi-Square tests return non-significant results ($p > 0.05$), confirming that inventory practices at BHEL Trichy are broadly uniform across demographic groupings. Notably, ERP adoption is consistent across all age groups (approximately 45% usage rate per group; Cramer's V = 0.067), suggesting that digital inventory adoption is not constrained by generational differences.

5.4 Spearman's Rank Correlation

Table 4 reports the eight statistically significant Spearman correlation pairs (all $p < 0.05$), extracted from a full correlation matrix of inventory management variables.

Table 4: Spearman's Rank Correlation — Significant Pairs

Variable 1	Variable 2	r	p
Inventory Shortage Impac (Q10)	Training Helps Managemen (Q23)	-0.286	0.002
Supplier Reliability–Interna (Q17)	Suggest Supplier Coordinatior (Q24)	0.262	0.006
Inventory Shortage Impac (Q10)	Records Updated Regularly (Q25)	0.221	0.020

Variable 1	Variable 2	r	p
Inventory Check Frequency (Q7)	Employees Trained (Q13)	-0.212	0.026
Work Experience (Q5)	Suggest Safety Stock (Q22)	0.205	0.032
Proper Inventory Records (Q6)	Suggest Safety Stock (Q21)	-0.199	0.036
Employees Trained (Q13)	Suggest Supplier Coordination (Q24)	-0.202	0.034
Work Experience (Q5)	Proper Inventory Records (Q6)	0.195	0.041

The correlation analysis reveals weak but statistically significant relationships. The strongest association observed is a negative correlation ($r = -0.286$) between perceived inventory shortage impact and endorsement of training as a solution, suggesting that employees who experience the most operational disruption prefer structural or systemic interventions over training.

6. Discussion

The empirical findings of this study converge on several themes that merit deeper interpretive engagement. First, the prevalence of ABC Analysis as the primary control technique (34.5%) confirms BHEL's commitment to selective inventory control — a particularly rational choice given the organisation's mix of high-cost boiler components and standard consumables. This finding is consistent with the supply chain optimisation literature (Chopra & Meindl, 2016; Beamon, 1998), which advocates value-based prioritisation in materials management.

Second, the high rate of ERP/SAP adoption (77.3% confirming computerised systems; 74.6% affirming ERP effectiveness) aligns with Gunasekaran and Ngai (2004) and Ivanov et al. (2017), who argue that digital integration is foundational to supply chain performance. However, the 36.4% of employees without inventory software training represents a critical human capital gap that risks undermining technological investments — a finding that should be treated as a priority intervention area for management.

Third, the identification of supply delays as the dominant challenge (34.5%) and the 50/50 split on external supplier reliability underscore the vulnerability of BHEL's supply chain to external disruptions. Tang (2006) advocates risk pooling and strategic sourcing as mitigating strategies, both of which appear underutilised given that only 54.5% rate their suppliers as reliable. The 76.4% employee recommendation for improved supplier coordination further signals that workers on the ground recognise this as the most actionable leverage point.

7. Implications

7.1 Managerial Implications

- BHEL management should invest in a structured, department-specific training programme for SAP/ERP inventory modules, targeting the 36.4% of employees currently without software training.
- A supplier performance monitoring framework — incorporating KPIs for on-time delivery, quality, and lead time — should be formalised and linked to procurement decisions, given the 50/50 split on supplier reliability.
- Automation of inventory processes, endorsed by 29.1% of respondents as the top improvement priority, should be piloted in the HPBP and SSTP units where high-value component flow is most critical.

8. Limitations

This study is subject to several limitations that should be considered when interpreting findings. First, the sample of 110 respondents, while statistically functional, may not fully represent the full organisational diversity of BHEL Trichy's 29,000+ workforce. Second, the study is geographically confined to the HPBP and SSTP units of the Trichy complex, limiting the generalisability of findings to other BHEL manufacturing units or similar EPC enterprises.

9. Future Research Directions

Future research should consider the following directions to build upon and extend the present study:

- A longitudinal study examining inventory performance metrics (holding costs, stockout frequency, order cycle times) before and after ERP system upgrades would provide causal evidence for digital transformation ROI.
- A multi-site comparative study across BHEL's 16 manufacturing units could identify best practices and enable benchmarking across the organisation.

10. Conclusion

This study provides a comprehensive empirical assessment of inventory control efficiency within the project logistics framework of BHEL Trichy. The evidence supports the conclusion that BHEL follows broadly systematic and effective inventory management practices, with strong adoption of ABC Analysis, computerised ERP systems, and safety stock protocols. A majority of employees (74.5%) express satisfaction with the current system, and the organisation has successfully established foundational inventory control infrastructure.

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