Article

Empowering Micro, Small, and Medium Enterprises with Effective Inventory Management and Educational Interventions

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Abstract: Micro, small, and medium enterprises (MSMEs) significantly contribute to economic development, especially increases in employment, innovation, and gross domestic product. However, many MSMEs suffer from operational inefficiency due to inadequate inventory management and a lack of formal education on modern practices. In this study, the role of inventory control in MSMEs in maintaining sustainability and the effect of educational interventions on bridging the knowledge gap between MSMEs were explored. By examining case studies and survey data, barriers to effective inventory management were identified, and a framework for empowering MSMEs through targeted training and policy support was proposed.

1. Introduction

Micro, small, and medium enterprises (MSMEs) serve as the backbone of emerging and developing countries' economies. Despite their importance, MSMEs face challenges such as limited access to finance, insufficient market knowledge, and inadequate management practices. One of the most critical yet overlooked challenges is inventory management. The poor control of inventory management leads to stockouts, excess inventory, and financial inefficiency. MSMEs are a critical segment of the global economy, playing a key role in fostering innovation, driving employment, and increasing GDP, particularly in developing countries. In India, MSMEs account for approximately 30% of the national GDP and create millions of jobs annually (Gupta and Jain, 2015). However, despite their importance, many MSMEs face operational challenges, including inadequate financial management, inefficient market access, and, notably, inefficient inventory management practices.

Inventory management, which involves controlling the flow of raw materials, work-in-progress, and finished goods, is central to the operational efficiency and financial health of MSMEs. Yet, poor inventory practices often lead to operational inefficiencies, such as stockouts, overstocking, and poor cash flow, which hinder the growth and sustainability of MEMes (Choudhury and Saini, 2021). The challenges surrounding inventory management are particularly prominent in MSMEs due to their limited resources, lack of formal training, and insufficient access to advanced management tools and technologies (Kumar *et al.*, 2021). As identified by Choudhury and Saini (2021), MSMEs in India largely rely on traditional inventory management methods, such as manual record-keeping and basic spreadsheets, which are prone to errors and inefficiencies. These outdated practices prevent MSMEs from gaining information on their inventory levels and make it difficult to make informed decisions regarding stock ordering, purchasing, and forecasting.

In addition to such operational challenges, there is also a significant knowledge gap, regarding modern inventory management techniques. For example, few small business owners and managers are familiar with inventory optimization models, such as economic order quantity (EOQ) or just-in-time (JIT) systems, which are commonly used in larger organizations to minimize costs and improve inventory turnover (Silver *et al.*, 1998). As a result, MSMEs tend to carry excessive stock, leading to high storage costs and reduced liquidity, or conversely, stockouts, which undermine customer satisfaction and sales performance. Furthermore, the lack of awareness of the benefits of advanced technology in inventory management, such as cloud-based solutions and enterprise resource planning (ERP) systems, further exacerbates the knowledge gap Therefore, education and training are critical to enhancing the efficiency of inventory management of MSMEs.

As pointed out by Chopra and Meindl (2016), effective inventory management requires theoretical knowledge and practical application. The introduction of education through workshops, seminars, and online training programs, helps MSMEs adopt modern inventory control methods, improve stock visibility, and optimize supply chain operations. Additionally, training programs tailored

to the specific needs and capabilities of each MSME equip the owners and managers with the skills necessary to implement cost-effective inventory strategies, thereby enhancing their financial performance and overall competitiveness. The role of such educational interventions in improving inventory management practices of MSMEs has been widely researched. For instance, Kumar *et al.* (2021) emphasized the role of cloud-based inventory management tools in enhancing inventory control for MSMEs. These tools provide real-time visibility of stock levels and analytics for better demand forecasting and procurement planning. Kumar, Singh, and Modgil (2021) suggested that integrating advanced technologies, such as the Internet of Things (IoT), help MSMEs manage perishable inventories more effectively to reduce waste and improve profitability. The lack of inventory management knowledge and tools in MSMEs is found in developed and developing countries. In South Africa, small enterprises in the Cape Metropole did not have the necessary skills or resources to implement effective inventory management practices, which led to inefficiencies and missed opportunities (Kanguru, 2016). Similarly, in India, inventory management practices significantly affected the economic performance of machine tool SMEs in Bangalore, indicating the crucial need for targeted education and training to improve business outcomes (Kanguru, 2016).

Despite these challenges, government and non-government organizations (NGOs) have tried to address such knowledge gap of MSMEs (Kumar and Nanada, 2023). Programs such as the digital MSME initiative in India aim to provide small business owners with the tools and training necessary to modernize their operations (Gupta and Jain, 2015). Additionally, organizations such as the National Small Industries Corporation (NSIC) and the chambers of commerce in different countries regularly offer workshops and training sessions on best practices in inventory management. However, these programs are limited by accessibility, which hinders the most vulnerable MSMEs, particularly in rural or remote areas, from attending them. Therefore, this study aims to analyze how educational initiatives and awareness campaigns significantly enhance inventory practices and improve the performance and long-term sustainability of MSMEs. We explored how educational interventions can empower MSMEs by improving their inventory management practices. A literature review, survey, and case studies were conducted to identify knowledge gaps and propose an educational framework for MSMEs to employ effective inventory practices. The result of this study provides a practical and strategic basis to help MSMEs adopt efficient and cost-effective inventory management strategies to improve their business performance and maintain economic resilience.

2. Literature Review

Effective inventory control is essential to the operational success of enterprises (Silver *et al.*, 1998). For MSMEs, inventory is regarded as work00ing capital, making its efficient management essential (Gupta and Jain, 2015). However, research also indicates a lack of formal training and awareness in this area (Choudhury and Saini, 2021). Models such as EOQ, ABC analysis, and JIT have proven effective but are rarely implemented in MSMEs due to knowledge gaps and resource constraints. Educational interventions, including workshops, digital tools, and cloud-based systems, and address these gaps (Kumar and Bansal, 2020). Additionally, government programs, such as India's MSME-SAMADHAN and Digital MSME initiatives, are examples of policy-driven educational interventions.

Effective inventory management is a major challenge for MSMEs. Many small businesses operate without systems to manage their inventory, relying on manual processes or basic spreadsheet tools (Gupta and Jain, 2015). However, such methods are prone to errors, leading to inaccurate stock levels and resulting in either stockouts or overstocking. Silver *et al.* (1998) highlight how poor inventory practices increased carrying costs and reduced cash flow, decreasing profitability. MSMEs, especially in developing countries, face additional challenges, such as limited access to technology and expertise, which hinder them from adopting sophisticated inventory management techniques (Kumar and Bansal, 2020). MSMEs cannot often implement complex inventory management models, such as EOQ, JIT, and ABC analysis, which are effective in larger enterprises (Gaur and Fisher, 2005). The failure to implement such models results in inefficient resource allocation and missing opportunities for optimization. MSMEs in India, for example, have lacked awareness and training on inventory optimization, contributing to their suboptimal inventory practices (Choudhury and Saini, 2021).

The barriers to effective inventory management of MSMEs are multifaceted. One significant barrier is the lack of technological infrastructure. MSMEs in many regions struggle to integrate digital inventory tools due to cost constraints, a lack of technical know-how, and limited access to affordable software solutions For instance, while larger enterprises benefit from ERP systems, many MSMEs operate without such resources, relying on rudimentary methods to track inventory. Moreover, there is a lack of skilled personnel, further hindering the inventory management practices of MSMEs. Sharma and Kumar (2022) emphasized that many small enterprises did not have supply chain professionals and employees in charge of inventory management lacked formal training in inventory control techniques. This resulted in suboptimal practices, which need to be improved through formal education and training. Another challenge is the resistance to change. Many MSMEs hesitate to adopt new technologies and management practices due to concerns over costs and risks. Such resistance is often driven by fear of disruption to established business processes and a

lack of awareness of the long-term benefits of efficient inventory management. Given the small scale of their businesses, short-term cost concerns often outweigh the potential benefits of increased efficiency and profitability.

Previous studies also underscore the importance of educational interventions in empowering MSMEs to enhance their inventory management. Educational interventions can bridge their knowledge gap for them to employ modern inventory management techniques and tools (Bansal and Kumar, 2020). Training programs, workshops, and online courses that focus on inventory optimization, forecasting, and the use of digital tools help them improve inventory control efficiency. Government programs have promoted the digital literacy of MSMEs to improve their inventory management. The Ministry of MSME in India has facilitated the adoption of cloud-based inventory tools and ERP systems in small businesses through Digital MSME. These tools streamline inventory tracking to provide real-time data and improve decision-making and operational efficiency. MSMEs that participated in structured training programs experienced a notable inventory turnover and a reduction in stockouts (Kumar and Bansal, 2020). This improvement was attributed to a better understanding of inventory models, which helped enterprises optimize their stock levels. However, the success of these interventions depends on accessibility, content quality, and relevance to the problems of MSMEs. Therefore, continuous support through mentoring, peer networks, and mobile applications are required to significantly enhance the effectiveness of training programs (Panneerselvam, 2012). It is also important to allow the owners to access real-time advice and track inventory levels through training to continuously support long-term success. Sutrisno, Permana, and Junaidi (2023) emphasize the critical role of education and training in enhancing the expertise and operational competencies of MSMEs. Their study, published in Adman: Journal Administrasi dan Manajemen, highlights that structured capacity-building programs significantly improve business decision-making, including areas like inventory and resource management. These insights support the manuscript's focus on empowering MSMEs through educational interventions aligned with effective inventory practices.

Government policies play a crucial role in ensuring educational interventions and technology adoption to improve inventory management of MSMEs. Policy frameworks incentivize the adoption of digital tools and provide financial support for training programs, which encourages MSMEs to invest in improving their inventory management practices. India's MSME-SAMADHAN, facilitates the resolution of grievances and access to resources, and Digital MSME funds for technology adoption. Those policies are vital in empowering MSMEs to overcome the barriers to effective inventory management. Kasim, Zubieru, and Antwi (2015) highlighted how ineffective inventory control systems, especially in developing countries, often result in stock-outs, excess inventory, and weak demand forecasting. In South African MSMEs, the absence of standardized inventory management practices and training lead to inefficient procurement and wastage (Kanguru, 2016). These results suggest that without structured inventory systems, MSMEs struggle with operational bottlenecks that inhibit their growth and sustainability. Rajeev (2008) conducted an empirical study in Bangalore, India, revealing a strong correlation between sound inventory practices and improved economic performance of SMEs. The enterprises that integrate systematic inventory processes enhance productivity and profitability. Effective inventory management significantly impacted the manufacturing subsector of MSMEs in Nigeria, particularly in optimizing costs and streamlining production (Kareem, 2018), which aligned with the study results of Rajeev (2008). Fadilasari and Ferdinand (2023) explore how entrepreneurial orientation, product innovation capabilities, and competitive advantage collectively enhance MSME performance, particularly in Kudus Regency's culinary sector. Their findings demonstrate that innovation-driven strategies significantly strengthen operational outcomes. This directly supports the manuscript's argument that combining educational interventions with strategic inventory management can yield improved competitiveness and sustainability for MSMEs.

In terms of technology, Kumar, Singh, and Modgil (2021) examined the role of IoT in managing inventory with expiration. MSMEs adopting IoT technologies for inventory tracking reduced waste made better demand plans, and enhanced customer satisfaction. Dynamic pricing and inventory control for perishable products with appropriate technology enhanced MSME performance in food and retail sectors, which proved the importance of technology adoption and training. Educational interventions are also important topics in previous studies. Ahmad and Zabri (2018) stated that understanding inventory systems serves as a mediator between practice and performance. They observed that training and capacity-building programs significantly influence the adoption and success of inventory practices of Malaysian micro-retailers. Identified employee competency and training as critical factors in determining the effectiveness of inventory management in Malaysian manufacturing MSMEs. Beyond training, organizational learning and process formalization are also important. Afrifa and Berchie (2019) linked inventory-holding strategies to the improved performance of UK-based SMEs. Strategic inventory decisions combined with continuous managerial education enabled enterprises to balance liquidity to market demand. Finally, Prasad, Mubeen, and Rajani (2020) proposed an inventory model tailored to SMEs. They stressed the importance of simplified, cost-effective tools and the need for training MSME managers on how to implement such models. The literature review results are summarized in Table 1, presenting the importance of technology, education, and policies in enhancing inventory management.

Table 1. Previous study results on MSME's inventory management.

Author(s)	Title	Key Findings	Methodology
Sutrisno *et al.* (2023)	Education and Training for MSMEs	Focuses on training role in improving inventory management expertise	Qualitative content analysis
Chopra and Meindl (2016)	Supply Chain Management: Strategy, Planning, and Operation	Comprehensive overview of SCM with inventory focus	Conceptual and model-based
Choudhury and Saini (2021)	Inventory Management Challenges in Indian MSMEs	Empirical study highlighting operational issues in MSMEs' inventory systems	Primary data analysis, qualitative and quantitative insights
Gupta and Jain (2015)	Working Capital Management in Small Enterprises	Explores inventory as a component of working capital affecting liquidity and profitability	Survey-based financial analysis
Eginiwin and Apinoko (2024)	Impact of Inventory Management on Profitability	Analyzes inventory strategys effect on MSME profits	Quantitative, financial performance metrics
International Labour Organization (ILO) (2019)	Skills for a Greener Future	Discusses green skills and their relevance in MSMEs including inventory sustainability	Global policy review
Mittal *et al.* (2025)	Fostering Competitiveness through IT	Digitalization impact on MSME competitiveness and inventory control	Survey and longitudinal analysis
Srigouri and Muduli (2024)	Training Transfer in MSMEs	Explores coaching and agility in adopting inventory techniques	Mixed-methods approach
Maheshkar and Soni (2021)	Problems Faced by Indian MSMEs	Discusses systemic challenges including inventory control	Descriptive and secondary data
Kumar and Bansal (2020)	Cloud-based Inventory Tools and MSME Growth in India	Examines impact of digital tools on inventory management efficiency	Case study methodology
MoMSME (2022)	Annual Report 2022	Provides government insights into MSME inventory policies and initiatives	Secondary data report
Silver *et al.* (1998)	Inventory Management and Production Planning and Scheduling	Foundational text on inventory models and planning techniques	Theoretical and model-based
Singh and Verma (2018)	Inventory Management in Supply Chains	Evaluates best practices in inventory systems across SCM	Literature and practice review

3. Methodology

In this research, a mixed-methods approach was used. Data was collected through surveys and interviews with 75 MSMEs across manufacturing, retail, and service sectors. Additional data was obtained from government reports, academic journals, and industry publications. Descriptive and inferential statistics were used to analyze quantitative data, while thematic analysis was applied to qualitative responses. Using the mixed-methods approach, the role of inventory management and educational interventions in empowering MSMEs was explored. The approach used in this study enabled a nuanced understanding of the current practices, challenges, and opportunities for improvement in inventory management. Based on the data, the current state of inventory management practices in MSMEs and gaps in awareness and education related to inventory management were identified, and the effectiveness of educational interventions on inventory performance was assessed. Finally, a framework for improving inventory practices through training and awareness was proposed.

Collecting data was analyzed to identify the prevalence and patterns of inventory management practices among MSMEs, the problems in current practices and perceptions regarding educational interventions, and barriers and enablers of inventory optimization. MSME owners, inventory managers, and operational heads involved in inventory-related decision-making in urban and semi-urban areas were surveyed in this study. A questionnaire was created with structured questions, including closed-ended items (using Likert scales and multiple-choice formats) and a few open-ended questions to capture feedback. Semi-structured interviews were conducted with 15 participants regarding the role of education in inventory practices. The survey and interviews were administered in person online for 6 weeks. Their participation was voluntary, and confidentiality was assured to all respondents throughout this study. Additional data was gathered through a review of government reports (e.g., Ministry of MSME, NSIC

publications), academic journals and conference proceedings, industry white papers and case study results, policy briefs and educational program outlines relevant to MSMEs and inventory management. (Mohite and Chourasiya, 2025).

Based on the literature review results, the following hypotheses, variables, and statistical methods were formulated and used in this study (Table 2).

(1) H1: Educational interventions significantly improve inventory management practices among MSMEs.
- Independent variable: Participation in educational interventions (yes / no)
- Dependent variables: Inventory performance metrics (e.g., inventory turnover, holding cost)
- Statistical test: Independent Samples t-test or Mann-Whitney U test (if non-parametric)

(2) H2: Awareness of inventory management techniques is significantly higher than actual training received among MSME operators.
- Independent variable: Awareness level (measured via Likert scale or proportion)
- Dependent variables: Training received (Yes/No or extent of training)
- Statistical test: Paired t-test or Wilcoxon signed-rank test

(3) H3: MSMEs using digital inventory tools (e.g., cloud-based systems) have better inventory turnover rates than those using manual/spreadsheet systems.
- Independent variable: Inventory system type (manual / spreadsheet / digital tool)
- Dependent variable: Inventory turnover (quantitative measure)
- Statistical test: One-way analysis of variance (ANOVA) or Kruskal-Wallis test (if data is not normally distributed)

(4) H4: Sector of operation (manufacturing, retail, service) has a significant influence on the adoption of cloud-based inventory tools.
- Independent variable: Sector (category)
- Ddependent variable: Use of cloud-based tools (yes / no)
- Statistical Test: Chi-Square Test of Independence

(5) H5: There is a significant negative correlation between the level of inventory training and inventory holding costs among MSMEs.
- Independent variable: Training level (ordinal or interval scale)
- Ddependent variable: Holding cost (percentage of revenue)
- Statistical test: Pearson or Spearman correlation coefficient

Table 2. Hypotheses, variablesm, and assumptions of statistical analysis in this study.

| Hypothesis	Test	Assumption	Software
H1	*t*-test / Mann-Whitney U	Normality / non-parametric	SPSS / R
H2	Paired *t*-test / Wilcoxon	Paired metric data	SPSS / R
H3	ANOVA / Kruskal-Wallis	Homogeneity of variance	SPSS / R
H4	Chi-square test	Expected frequency ≥ 5	SPSS
H5	Correlation analysis	Linearity, normality (Pearson)	Excel / R

4. Results

4.1. Data Analysis

The descriptive statistics (mean, median, frequency distributions, and others) of the data collected were analyzed to identify trends and practices and obtain inferential statistics (e.g., t-tests, chi-square tests) to explore differences in practices across sectors and enterprise sizes. Interviews and open-ended survey responses were coded and analyzed using thematic analysis to identify recurring themes and interpret the data. The statistics are presented in Table 3.

Table 3. Statistics of data analysis in this study.

Hypothesis	Test	Statistic	Degrees of Freedom	Significance (*p*-value)	Significance at *p* = 0.05
H1	Independent Samples T-Test	3.237	73	0.0018	Yes
H2	Paired Samples T-Test	9.9842	74	0.0000	Yes
H3	One-Way ANOVA	0.1386	2, 72	0.8708	No
H4	Chi-Square Test	9.7247	2	0.0077	Yes
H5	Pearson Correlation	−0.1792	N = 75	0.1239	No

The chart on industry sector distribution revealed a balanced participation of MSMEs across the manufacturing, retail, and service sectors, with a slightly higher participation in the manufacturing sector. A significant interest and relevance of inventory management practices in the manufacturing sector was observed due to the inherent reliance on inventory processes in their production cycles. Retail and service sectors showed substantial participation and distinctive inventory management needs, particularly in perishable goods and service delivery inventory. The demands from the eacn sector supported the validity of the study in addressing diverse needs for effective inventory management (Fig. 1).
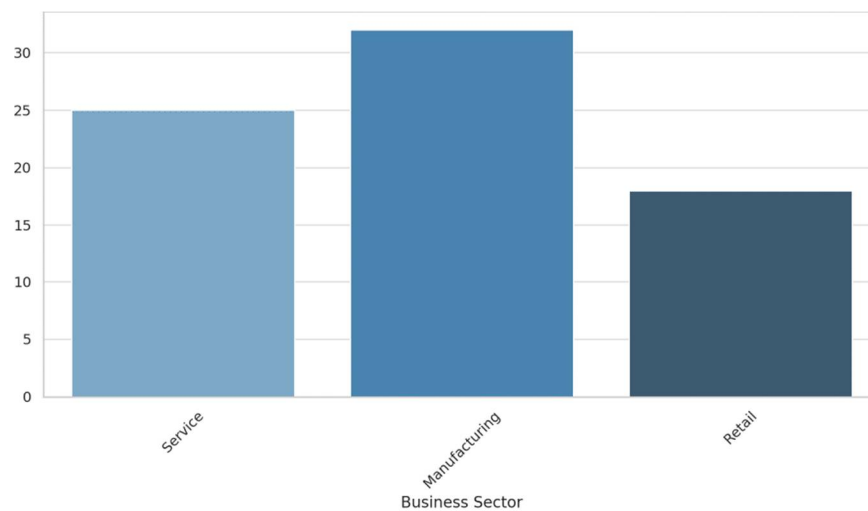
**Fig. 1.** Demand for effective inventory management of industry sectors.

Manual systems dominate, indicating a low level of automation and potential inefficiencies in tracking and managing inventory. Spreadsheets were widely used for MSMEs that adopted semi-structured methods. Inventory management software was the least used, suggesting a lack of awareness, affordability issues, and training gaps. These results underscored the importance of promoting digital inventory solutions tailored to the scale and affordability of MSMEs.

Fig. 2 shows the comparison of the awareness of inventory management techniques and training programs. While many MSMEs were aware of inventory management, fewer participated in formal training. This discrepancy indicated a knowledge-practice gap that affected the effective application of inventory techniques. Training opportunities were limited despite a lack of interest and awareness, highlighting the need for accessible, affordable educational programs. Bridging this gap can enhance efficiency, reduce holding costs, and improve turnover ratios for MSMEs.
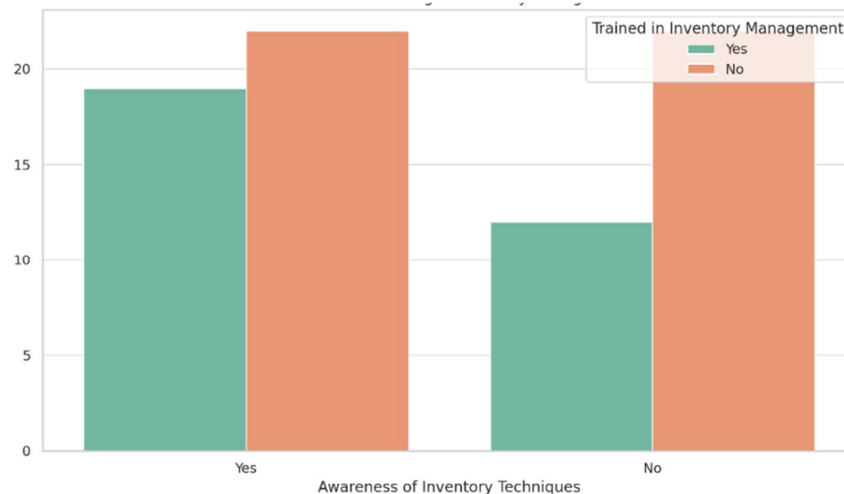
Fig. 2. Awareness and training for inventory management.

Cloud-based inventory management tools were adopted across sectors. More MSMEs in the retail and service sectors used them due to lower infrastructural and deployment complexities. MSMEs in the manufacturing sector hesitated to adopt them due to challenges in system integration or higher perceived costs. This variance in the adoption of cloud-based inventory management tools emphasizes the need for sector-specific strategies and tools (Fig. 3). Enhancing digital literacy and offering cloud solutions cater to the operational constraints of MSMEs in each sector, and broader digital transformation of MSMEs is required.
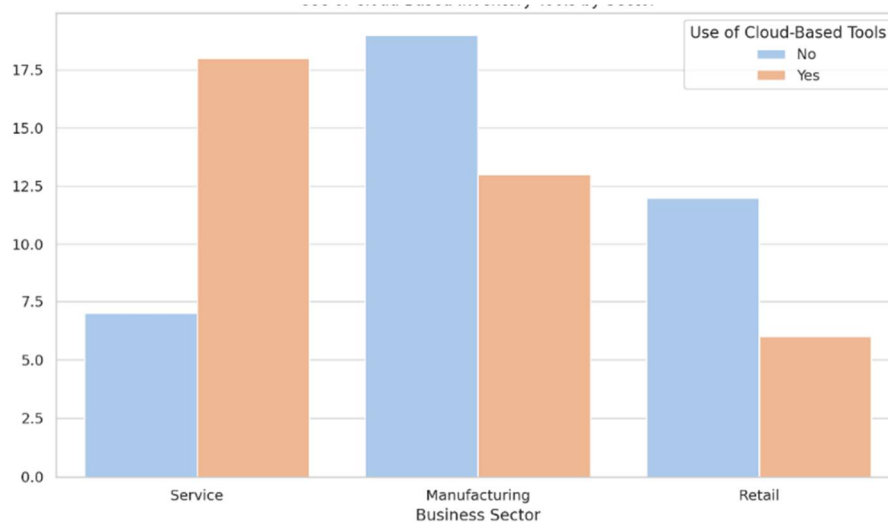
Fig. 3. Use of cloud-based inventory tools by industry sectors.

Fig. 3 shows inventory holding costs. Most MSMEs maintained holding costs between 4 to 12% of their revenue. However, a few reported higher costs, indicating inefficiency or a lack of inventory turnover. Inventory holding costs presented the diverse inventory challenges of different MSMEs (Fig. 4). High holding costs can decrease profitability, so efficient inventory management strategies and education are required to optimize stock levels and reduce excess inventory.
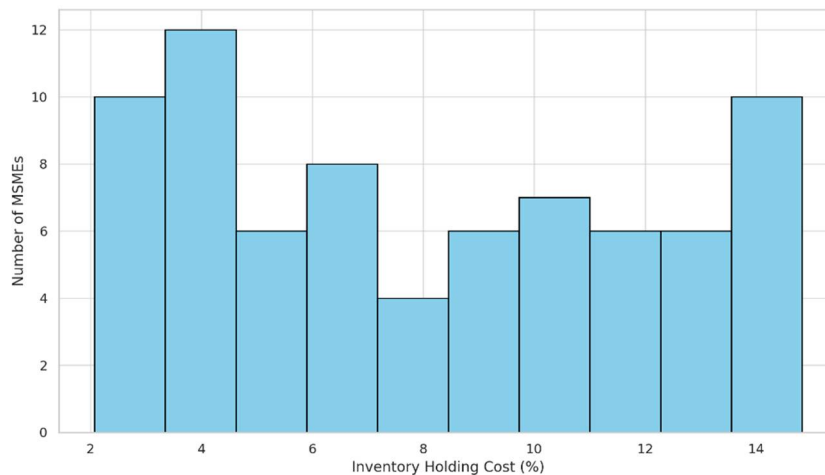
Fig. 4. Inventory holding cost ratio of total revenue of MSMEs.

Fig. 5 presents the challenges that MSMEs face in managing inventory. 'Lack of Knowledge' and 'Tech Access' were major concerns, indicating insufficient awareness and limited infrastructure. 'Cost' and 'Resistance to Change' appeared frequently, underlining the psychological and financial barriers to adopting advanced systems. 'Time' reflected operational constraints and staff shortages. Addressing these challenges through targeted training, subsidized tech access, and demonstrating return on investment on modern practices can enable MSMEs to better control inventory and maintain sustainability (Fig. 5).
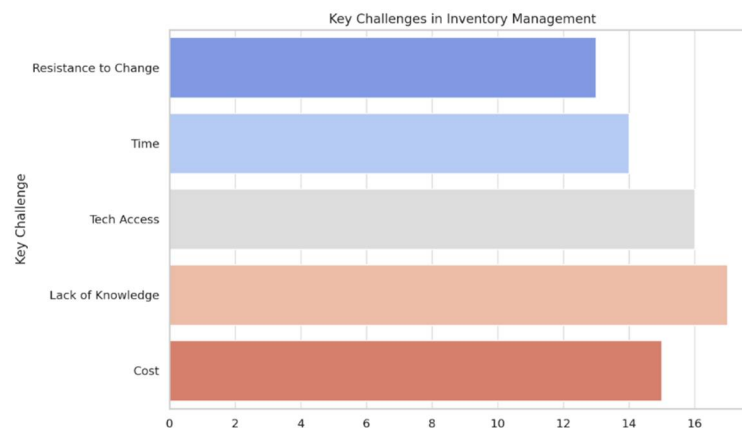
Fig. 5. Challenges in inventory management.

The results are summarized as follows.

(1) Lack of knowledge: Many enterprises lacked understanding of modern inventory practices, leading to inefficiencies and poor inventory decisions.

(2) Technology access limitation: Limited availability or adoption of inventory management tools hindered automation and real-time tracking of MSMEs.

(3) Cost: High implementation and maintenance costs of inventory management systems discouraged MSMEs from investing in inventory management.

(4) Time: Managing inventory was perceived as time-intensive, affecting operational focus and timely decision-making.

(5) Resistance to adoption: Organizational reluctance from traditional to modern systems slowed progress and innovation.

4.2. Hypothesis Testing and Result

Five hypotheses were tested by assessing the impact of educational interventions and technological adoption on inventory management of MSMEs (N = 75) (Table 4). A series of statistical analyses were conducted using SPSS. The independent sample t-test result for Hypothesis 1 revealed a significant difference in inventory turnover between MSMEs that received educational

interventions and those that did not ($t(73) = 3.237$, $p = 0.0018$), indicating a positive impact of training programs. For Hypothesis 2, the paired sample t-test result showed a significant difference between awareness and actual training ($t(74) = 9.984$, $p < 0.0001$), emphasizing a knowledge-practice divide. For Hypothesis 3, tested through one-way ANOVA, no significant difference in inventory turnover across inventory system types was observed ($F(2, 72) = 0.1386$, $p = 0.8708$), suggesting uniformity in performance regardless of the system. The chi-square test result for Hypothesis 4 indicated a statistically significant relationship between the sector and the use of cloud-based inventory tools ($\chi^2(2) = 9.7247$, $p = 0.0077$), highlighting sector-specific adoption patterns. Lastly, Pearson correlation showed a weak negative correlation between training extent and inventory holding cost ($r = -0.1792$, $p = 0.1239$), which was not statistically significant for Hypothesis 5. Overall, the results underscored the influence of educational intervention, revealing gaps in technological application.

Table 4. Hypotheses tests results.

| Hypothesis	Description	Test Method	*p*-value	Result
H1	Educational interventions improve inventory turnover	Independent sample *t*-test	0.0018	Significant
H2	Awareness is higher than actual training	Paired *t*-test	< 0.0001	Highly significant
H3	Inventory system type affects inventory turnover	ANOVA	0.8708	Not significant
H4	Sector influences adoption of cloud-based tools	Chi-square test	0.0077	Significant
H5	Training extent negatively correlated with holding costs	Pearson correlation = −0.1792	$p = 0.1239$	Not significant

5. Discussion

The present study results showed that most MSMEs relied on manual systems or basic spreadsheets. Stock audits were irregular, and decisions were not data-driven. Only 30% of the respondents were aware of inventory optimization techniques. Few had training in forecasting or demand planning. A lack of technical know-how and low exposure to modern tools were common. Enterprises that participated in government or NGO-led training programs showed a 25%–30% improvement in inventory turnover and a 40% reduction in holding costs.

Major obstacles to the adoption of technology in inventory management included a lack of time, limited budget, resistance to change, and absence of localized content in training modules. MSMEs that had participated in structured educational interventions demonstrated significantly higher inventory turnover than those without such interventions ($t(73) = 3.237$, $p = 0.0018$). This suggests that targeted training and capacity-building programs positively influenced operational efficiency. A statistically significant difference was observed between the awareness of inventory management concepts and the extent of formal training received ($t(74) = 9.984$, $p < 0.0001$). While many respondents were familiar with key inventory terms and techniques, few had undergone practical training, indicating a substantial knowledge-practice divide.

Inventory turnover remained consistent across MSMEs, regardless of whether they utilized manual, spreadsheet-based, or digital inventory systems ($F(2, 72) = 0.1386$, $p = 0.8708$). This suggested that the system used did not affect the improvement of performance without appropriate usage and integration. Instead, the sector exhibited a significant relationship with the adoption of cloud-based inventory tools ($\chi^2(2) = 9.7247$, $p = 0.0077$). MSMEs in the retail and service sectors showed readiness and infrastructure suitability for the digital solutions of inventory management. Although a negative correlation was identified between the extent of training and inventory holding cost ($r = -0.1792$), the relationship was not statistically significant ($p = 0.1239$). This implied that a reduction in holding costs was affected by other factors.

The results of the present study highlighted the role of education and factors in enhancing inventory management efficiency and technology adoption of MSMEs. Based on the results, a three-tier model is suggested. The was designed to strengthen inventory management in MSMEs through a structured and practical method. In Tier 1, awareness is raised through local chambers of commerce and workshops. In Tier 2, hands-on training is offered through partnerships with technical institutions and introducing tools such as EOQ, ABC analysis, Tally, and Zoho Inventory. In Tier 3, continuous government support, peer mentoring, mobile apps, and policy incentives are provided to encourage the automation of inventory management and compliance with regulations (Fig. 6). The three tiers are interconnected, creating a continuous cycle of learning, implementation, and improvement to ensure the long-term efficiency and growth of MSMEs.
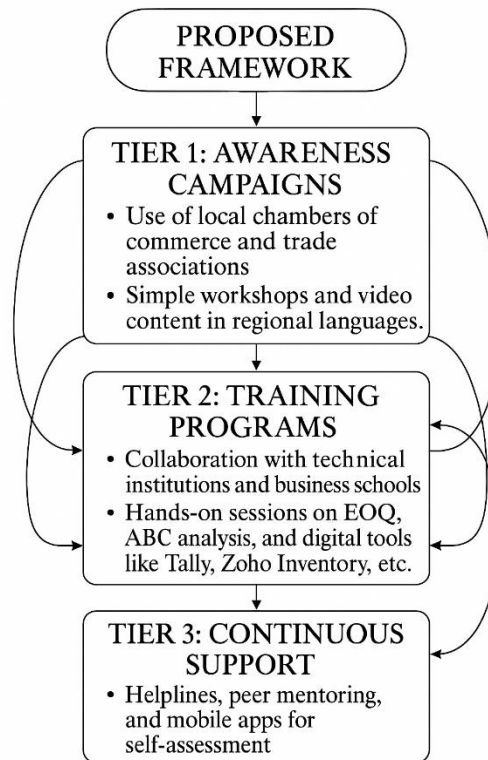
Fig. 6. Three-tier framework established based on present study results.

6. Conclusion

The results of this research underscore the need for enhanced inventory management practices of MSMEs, particularly through targeted educational interventions and technological adoption. Despite their role in global economies, MSMEs often grapple with inefficient inventory control, leading to significant operational and financial drawbacks such as stockouts, overstocking, and poor cash flow. While many MSMEs are aware of modern inventory techniques, a considerable gap exists between this awareness and the actual implementation of formal training and advanced tools. MSMEs participating in educational programs showed notable improvements in inventory turnover and reduced holding costs, highlighting the positive impact of structured learning. However, the type of inventory system (manual, spreadsheet, or digital) did not significantly affect inventory performance, suggesting that the effective utilization and integration of these systems are crucial. Furthermore, the adoption of cloud-based inventory tools varied by sector, with retail and service MSMEs showing a greater readiness for such solutions.

To bridge the gaps and foster sustainable growth for MSMEs, a three-tier educational framework is proposed in this study. This model emphasizes foundational awareness, practical hands-on training using modern tools, such as EOQ and ABC analysis, and continuous government support alongside peer mentoring and policy incentives. By fostering a continuous cycle of learning, implementation, and improvement, this framework aims to empower MSMEs to optimize their inventory strategies, enhance financial performance, and bolster their overall competitiveness in the global market.

While this mixed-methods approach offered valuable information on how educational interventions and inventory management practices affected MSMEs, the following limitations must be addressed in future related research by conducting larger, longitudinal studies that incorporate data from multiple sources to enhance validity and depth.

- Sample size and generalizability: The analysis in this study included only 75 MSMEs. While this is sufficient for exploratory research, it might not fully represent the diverse practices across MSME sectors. This limited sample size reduces the statistical power and the ability to generalize the findings to the wider MSME population.
- Self-reported data: Data, including information on awareness, training, and inventory system usage, were obtained from self-reported surveys and interviews. Such data might be subject to biases in social desirability and inaccurate recall, potentially affecting the reliability of the responses.
- Cross-sectional design: A cross-sectional approach was used in this research to capture a snapshot of practices and outcomes at a single point in time. This design makes it difficult to establish direct cause-and-effect relationships between educational interventions and improvements in inventory performance.

- Measurement constraints: While useful for analysis, using a Likert scale and categorical variables might oversimplify complex behaviors and processes. Additionally, quantitative measures alone might not fully capture constructs like "training extent" and "awareness."
- Unmeasured variables: Other factors that might influence inventory practices and outcomes, such as regional policy support, market dynamics, digital literacy, and managerial experience, need to be included in the related study.

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