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Comprehensive Review of Improvement in Inventory Management Methods through Digitalization: Traditional Practices and Emerging Trends

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Abstract

Efficient inventory management is necessary to enhance supply chain performance. Traditional models such as economic order quantity (EOQ), just-in-time (JIT), material requirements planning (MRP), and reorder point (ROP) fail to satisfy the demands in the current dynamic supply chain. This study tries to perform a comparative review of these methodologies in integration with emerging digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), radio frequency identification (RFID), and blockchain. The research evaluates each method in terms of effectiveness, adaptability, scalability and implementation complexity based on various academic and industry sources. Traditional systems remain cost-effective in a stable context; however, they frequently lack the responsiveness required in technology-driven inventory management. On the other hand, digital tools provide greater transparency and predictive capabilities, but they are more challenging due to performance cost and technical barriers. To address this gap, this paper describes both methods and compares them to identify weaknesses and strengths and offers an insight into a hybrid model that integrates the strengths of both paradigms. This approach may facilitate a slight transition toward digitalization, leading to greater resilience and operational efficiency. The findings tend to inform both practitioners and researchers interested in optimizing inventory strategies.

Keywords
Inventory Management, Digital Transformation, Supply Chain, Inventory Optimization.

1. Introduction
Inventory optimization directly affects cost management, quality of service, and efficiency of operations in supply chain effectiveness. Traditional approaches such as EOQ, JIT, ROP, MPR, and ABC analysis have provided framework inventory planning and control systems with the aim of being cost-effective and simple to apply in static contexts. But their dependence on 'static demand forecasts,' linear supply chain assumptions, and less flexibility and more frequently results in challenges in coping with the realities of modern volatility (Munyaka and Yadavalli 2022). However, in the context of globalization, supply chain complexities, and the demands of Just-In-Time (JIT) responsiveness, the assumptions of such traditional systems are being challenged. Traditional inventory management frameworks, such as Economic Order Quantity (EOQ) analysis, are effective in the maximization of order quantities and inventories in steady-state industrial environments; however, their inability

to facilitate real-time decision-making and address uncertainty has been causing problems over the last several years (Guo et al. 2024).

Meanwhile, rapid development of digital technologies such as artificial intelligence, machine learning, Internet of Things, radio frequency identification and blockchain is radically changing procedures in inventory management (Ferdousmou et al. 2024; Gupta 2022). These technological developments offer huge possibilities. A concrete example can be found in the retail beverage market, where the adoption of machine learning-based forecasting led to a 38.71% and 19.72% drop in forecast errors for milk and tapioca, respectively while at the same time improving delivery efficiency by 51.42% regarding On Time in Full (OTIF) service levels (Quiroz et al. 2025). Blockchain technology is also allowing increased supply chain transparency and traceability, which are critical for managing product provenance and reducing risk. Despite the undeniable promise and growing adoption of these digital systems, their widespread implementation remains uneven across industries, particularly within small and SMEs, often hindered by high capital costs, complex integration challenges, and persistent skill gaps (Diriye Hussein and Muhudin, 2024). One key concern is that, while individual technologies and traditional approaches have been thoroughly analyzed, the literature is still quite fragmented, individually examining traditional and digital inventory models. This creates a significant knowledge gap in terms of the synergistic benefits of their combined use. The current research endeavors to fill this important gap through first making an extensive analytical comparison of traditional and new digital stock control systems, identifying their advantages, inherent limitations and applicability for individual environments. It then investigates real-world challenges of digital integration and possible operational inconsistencies. Finally, this study examines traditional and emerging methods and conducts a thorough comparison to identify the more robust, data-driven and adaptive inventory strategies required for navigating today's complex and changing supply chain demands. Furthermore, this study highlights current inventory management challenges as well as potential future areas of focus.

2. Research Methodology

Figure 1 is a representation of the analytical framework and the methodological approach employed in the current research. This figure allows for an overall clear picture of the methodology used and the findings obtained in the research. The study uses a systematic literature review approach to explore how inventory management practices have evolved from conventional approaches to computer-integrated systems. The objective is to identify their strengths, weaknesses of traditional and emerging inventory management methods, comparing methods and synthesizing insights that support the development of a hybrid framework suited for dynamic supply chains. This methodology presents four parts including comprehensive literature review, comparative analysis of traditional and emerging methods and discussion and finding.

The review begins with identifying the standard inventory management methods. Traditional models include EOQ, JIT, MPR, ROP, and ABC analysis. In parallel, emerging digital practices such as AI, ML, IoT, RFID, blockchain, Enterprise Resource Planning (ERP), and Big Data analytics were selected based on their prominence in recent inventory optimization literature.

The chosen articles were subjected to comprehensive analysis to permit systematic comparison of traditional and digital approaches on numerous parameters such as effectiveness, flexibility, complexity of integration, scalability, and traceability. The use of thematic coding allowed discerning between persistent strengths and weaknesses and their applicability across different contexts. This step included also determining integration difficulties and operational gaps occurring in individual implementations. From compiled evidence, there was constructed a composite conceptual framework. This framework proposes adopting and merging both the structural reliability and cost-effectiveness of traditional inventory systems and predictive ability, real-time management, and scalability offered by digital technologies. The framework, therefore, calls for an adaptive, evidence-based planning focused on developing resilience and streamlining operations in dynamic supply chain environments.

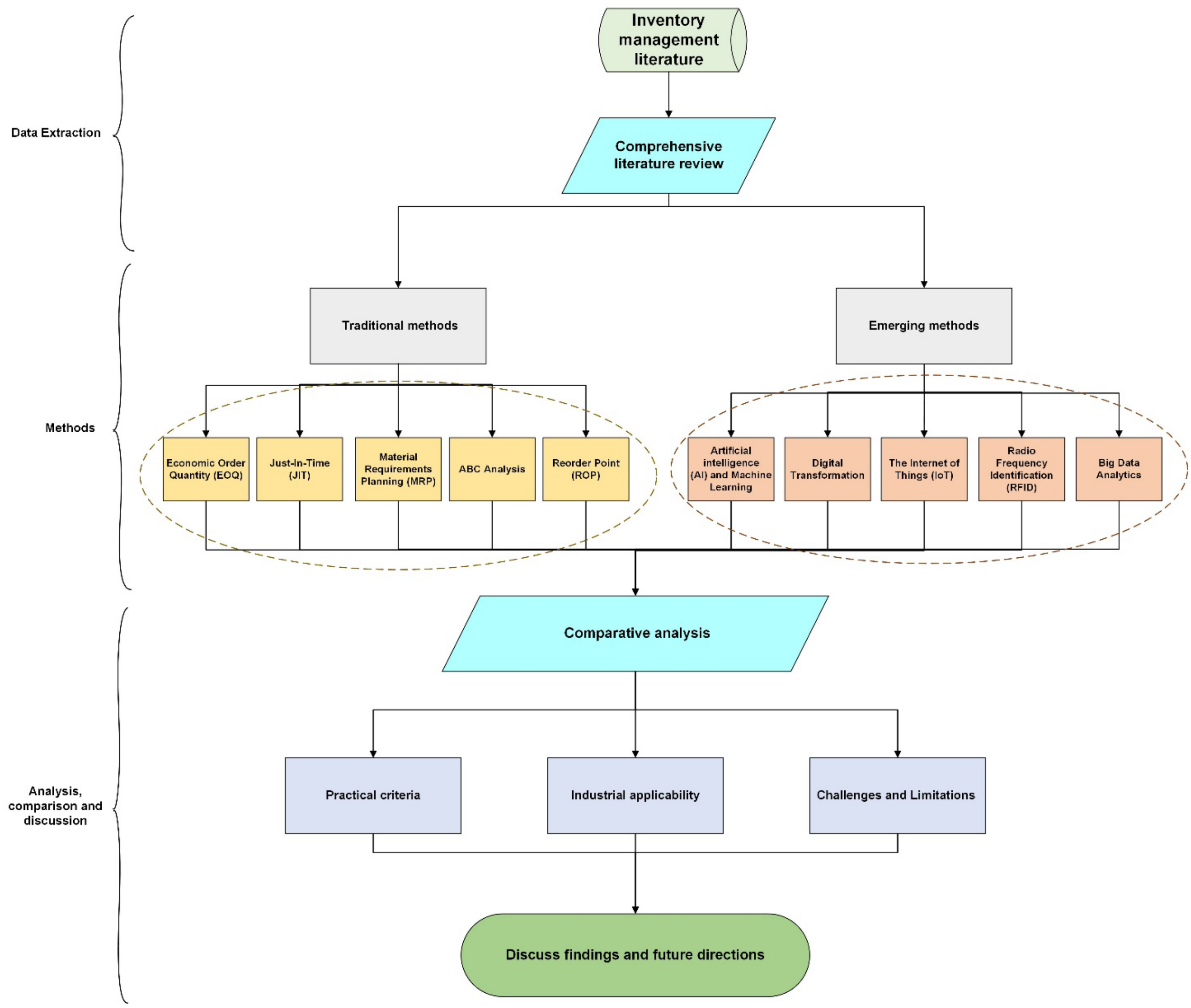

Figure 1. Study framework and workflow

3. Literature Review

Traditional inventory management methods, such as Economic Order Quantity (EOQ), Just-In-Time (JIT), Reorder Point (ROP), Material Requirements Planning (MRP), and ABC analysis, have long been used as both theoretical foundations and practical inventory control tools. These methods have allowed for inventory quantity optimization and cost minimization in environments that are relatively stable and predictable. Looking back at the issue highlights many limits. Top of these limits will be the reliance on deterministic assumptions, fixed lead times, stable requirements and low-variability context that is difficult to find nowadays in supply chains. The literature has suggested that such rigidity places organizations at increased risk of disruptions, volatile demand and large shocks within the supply chain that traditional models do not accommodate (Muppala, 2025). Despite attempts to develop these models further, a significant limitation remains with respect to standard models applied to circumstances with variability and randomness and which often reflects real-world practical instances.

Studies have shown that processes managing inventory have the potential to substantially change with technologies such as IoT, RFID, AI, ML, blockchain technology, and ERP (Ferdousmou et al., 2024; Gupta, 2022). Generally speaking, these technologies provide opportunities for precise forecasting, monitoring of inventory in real-time, and a more flexible manner of inventory operational practices. For instance, IoT enabled RFID systems have shown the potential to enhance inventory accuracy by 20% to 30% while achieving a dramatic reduction in tracking performatively (Madamidola, 2024). Furthermore, AI and ML provide predictive capabilities that enhance inventory decision-making through proactive and reactive techniques (Nweje, 2025).

Nonetheless, a critical review of the literature reveals numerous contradictions and unresolved issues. While case studies demonstrate the potential of digital transformation, systematic reviews show that adoption is uneven, particularly among SMEs, which are hampered by prohibitive costs, integration barriers, and skill shortages (Diriye Hussein and Muhudin, 2024). Furthermore, the literature is replete with optimistic projections, but there is little empirical evidence of long-term performance improvements or returns on investment, particularly outside of large-scale manufacturing or high-tech sectors (Madamidola et al. 2024). For instance, despite widespread enthusiasm for blockchain and AI, there is little research on how these technologies perform in resource constrained environments or how they deal with issues like data privacy, cybersecurity and technology obsolescence over time (Tiun et al. 2024).

Another significant gap is the siloed nature of most research; traditional and digital inventory management approaches are typically examined in isolation. Very few studies conduct direct empirical comparisons, analyze hybrid implementations, or offer guidance on effective sequencing and integration of methods (Fang et al. 2024). The breakdown of research hinders both academics and practitioners from successfully integrating best practices and understanding the potential trade-offs and synergies therein. Furthermore, much of the empirical examination focuses almost exclusively on the production or retail sectors, thus overlooking sectors like healthcare, agriculture, and logistics. These critical gaps and contradictions highlight the absence of a comprehensive inventory management solution. Traditional models are economic viability and reliability but have internal limitations in settings marked by rapid change and uncertainty (Munyaka and Yadavalli, 2022; Madamidola et al., 2024). Digital systems, on the other hand, are intelligent and adaptive but require resources, infrastructure and expertise that are frequently lacking in many organizations (Diriye Hussein and Muhudin, 2024; Ugbebor et al., 2024). An important shortcoming found in the existing literature relates to the lack of a coherent framework that unifies traditional and digital approaches such a framework would leverage the strengths of both (Fang et al., 2024; Skoumpopoulou et al., 2025). The current literature supports that researchers have suggested many solutions to solve this issue by combining traditional approaches with modern digital innovations and analytical techniques in order to increase the efficiency of inventory management. The literature cites that the blending of proven legacy models with the flexibility and capabilities of evolving technologies can provide a more integrated and solid framework customized to address the complex requirements of modern supply chains.

3.1. Overview of Traditional Inventory Management Methods

Traditional models have been the main tools used to manage inventory for many years. These methods were effective in reducing costs under stable conditions. This section explains traditional inventory management methods including EOQ, JIT, MRP, ABC Analysis and ROP, with particular attention to their advantages and limitations.

The EOQ model aimed at minimizing the total cost of inventory through the optimal balancing of ordering and holding expenses. The EOQ is derived using the formula.

$$\mathrm{EOQ} = \sqrt{\frac{2DS}{H}} \tag{1}$$

Where D is the annual demand, S is the ordering cost, and H is the holding cost per unit, per year (Shaikh and Raut 2020). The EOQ model has been found to have great uses in situations where operations are stable, demand is predictable, and lead times can be depended on. This model has been commonly used by the manufacturing and distribution companies that experience significant inventory costs (Khakbaz et al. 2024). The EOQ model has primarily been used because of the simplicity of their analytical model, which provides the decision-maker with a straightforward and easy-to-use method of developing suitable quantity models, without complex calculations and estimations. Furthermore, since the basic concepts of the EOQ model are uncomplicated, they can be easily combined with other inventory management methods, such as JIT methods that provide better operational efficiency, less lead time, and lesser costs of operation (Arun and Geetha, 2024). The conventional EOQ model makes overly optimistic assumptions that include constant cost, instantaneous replacement, and constant demand. These conditions are hardly the case for supply chains today. Under dynamic conditions with variability in demand, uncertainty in lead times, and more emphasis on sustainability, the model's relevance to real life is reduced (Madamidola et al. 2024).

The JIT inventory system, first developed by Toyota, focuses on complying inventory deliveries with actual production and customer demand. As a key part of lean manufacturing JIT aims to reduce excess stock, lower storage costs, and improve supply chain responsiveness (Olaniyi and Pugal 2024). It improves warehouse operation efficiency and supports flexible production systems by reducing waste and improving workflow. JIT production depends on reliable forecasting of demand and coordination with suppliers. In disrupted or infrastructure-constrained supply chains, JIT increases the risk of stockout when suppliers fail to meet delivery schedules (Swathi and Lavanya, 2025). Despite these drawbacks, JIT remains a viable cost-control measure, especially when supported by such technologies as predictive analytics, real-time tracking, and warehouse-integrated programs. Research continues to validate its role in ironing out the kinks and maintaining lean inventories in dynamic markets that change quickly.

MRP is a formal, computerized inventory management system designed to manage dependent demand materials in the manufacturing setting. Its major goal is to meet material availability for production with lower levels of inventory and thus coordinate purchasing to the master production schedule. MRP systems rely on three essential inputs like the master production schedule, the bill of materials (BOM), and current inventory data. Material Requirements Planning is a process that calculates net material requirements and creates scheduled order releases in order to enable uninterrupted manufacturing in multi-stage processes (Madamidola et al. 2024). Such MRP is useful in complex scheduling of assemblies whose complexity necessitates prompt material allocation. The accurate data makes MRP effective; however, forecasting demand, inventory, or scheduling errors could result in late production, duplicate inventories, and stockouts. Besides, despite MRP having high planning and coordination advantages, its achievement is subject to data accuracy and systems discipline.While MRP provides significant planning and coordination benefits, its effectiveness still depends on systematic discipline and data accuracy.

ABC analysis is a discriminatory approach to inventory management dividing inventory items into three groups: A, B, and C, depending on their utility value as well as their share of total inventory costs. The 'A' group is usually a minority of the total inventory but has a high share of inventory expenditure; therefore, these products are under strict control and monitoring. In contrast, the 'B' and 'C' groups represent increasingly lower levels of inventory priority corresponding with decreasing oversight. This categorization increases productivity of resources as well as directs management attention toward areas with largest operational benefits (Shaikh and Raut 2020). In addition, ABC analysis is especially helpful in situations with large quantities of items and limited management resources. However, financial focus of this approach can hide strategic problems, including fluctuations of lead time or supply chain vulnerabilities, so combining extra evaluation techniques would help accomplish holistic inventory management.

According to ROP systems, when the inventory reaches a certain level, they place a replenishment request. It has a simple design, ease of use, and is able to avoid stockouts, thus promoting uninterrupted production and service delivery (Madamidola et al. 2024). ROP models are often coupled with safety stock buffers and demand-planning techniques with the purpose of increasing reliability, counter lead time and consumption variability fluctuations and customer satisfaction.

The formula for Identifying a typical ROP is given as follows:
identifying

$$\mathrm{ROP} = (\text{Average Daily Demand} \times \text{Lead Time}) + \text{Safety Stock} \tag{2}$$

ROP is an effective method for both manufacturing and retailing situations where stable demand patterns and dependable lead times allow the accurate calculation of reorder levels (Shaikh and Raut 2020).

3.2 Emerging Trends in Inventory Management

The internal limitations of traditional models, particularly their inability to deal with today's complexities, has accelerated the transition to new, innovative digital solutions. The following section will look at new technologies that are transforming inventory management practices across organizations, shifting from a focus on cost-cutting and reactive thinking to an analytics-driven strategic approach. These technologies represent not only improvements but also a significant redesign of inventory visibility, management and usage throughout the supply chain. In this section, the article reviews advanced inventory management methods including AI and ML, Digital transformation methods, Blockchain, IoT, RFID and Big data analytics and also integration of this methos as hybrid inventory management.

AI and ML are revolutionizing inventory control because they replace static assumption-based systems with dynamic learning-based systems. AI can analyze complex, non-linear relationships in real time, allowing for drastic gains in forecasting, automation and decision making. one of the greatest benefits of AI is the transformational impact on demand prediction. By analyzing a number of datasets such as historical sales, seasonality and external influences, AI algorithms are better able to be accurate. For instance, for highly volatile markets such as perishable foods, AI systems can dynamically predict demand and automate delivery timetables to minimize the risk of spoilage (Zhao et al. 2025). This prediction is complemented by the ability of ML to include a range of real-time indicators such as weather and social networking site usage, which are more difficult for traditional techniques to include (Samuels 2025; Huerta-Soto et al. 2025).

In addition to prediction, AI is enabling automation of key inventory operations. Beyond prediction, AI also enables automation of crucial inventory activities. Methods of reinforcement learning are capable of building self-learning agents which decide optimal ordering policy in intricate environments like drug supply chains and minimize stockout cost and wastage (Kaur and Prakash, 2025). On ground physical warehouse floor level, computer vision platforms backed by convolutional neural networks are enabling automation of the labour intensive and error-ridden process of inventory counting at much higher accuracy and speed (Villegas-Ch et al. 2024).

Digitalization impacts inventory management significantly by enhancing the method applied by companies to inventory management, managing and regulating stock levels in complex supply chains. Two top technologies driving the transformation are ERP systems, Warehouse Management Systems (WMS), and cloud computing. All of them promote increased operational visibility, automation, and responsiveness. ERP systems integrate the key activities of businesses such as purchasing, logistics, finance, and manufacturing into a single system. The integration ensures direct access to the data through which better-informed decisions are made and minimizes errors and inefficiencies (Zhu, Zhao and Yao 2024).

Integration of the ERP systems and the WMS makes the warehouse management efficient. It gives high accuracy in tracking the stock and minimal need for intervention by humans. A well-implemented ERP and WMS provide end-to-end visibility of the supply chain, enabling adjustments according to demand changes. Cloud technology provides the basis for such systems because it promises remote access, real-time collaboration and effortless integration with AI and ML tools. Such capabilities enable predictive analytics and forecasting of inventories, reduce IT infrastructure costs, and enhance the ability to scale (Fang, Zhou, Jiang and Li 2024). However, small and medium-sized businesses encounter problems in implementing such systems due to limited resources and digital readiness. Modular software systems are best for regions with an underdeveloped physical infrastructure. Besides, digital platforms facilitate combined logistics and global sourcing through the integration of global supply chain players (Skoumpopoulou et al. 2025). System interoperability, organizational readiness, and a focus on cybersecurity are all required for smooth deployment.

Blockchain technology has transformed inventory management by increasing supply chain visibility and traceability. Basically, blockchain is an immutable and decentralized ledger in which all inventory transactions and movements are securely stored and cannot be altered in the past. The fundamental nature allows for the creation of tamper-proof records so that the stakeholders are in a position to track the products from the source to the final point of consumption.

blockchain technology can improve an inventory management system. It provides end-to-end visibility throughout the entire life cycle of the inventory and creats a standardized, trustworthy and visible ledger to all approved stakeholders. This visibility reduces the risk of fraud, counterfeiting, and discrepancies in data across supply chain stakeholders. It is is highly applicable in industries where authenticity and compliance with regulatory requirements are importance like pharmaceuticals and aerospace, (Ho et al. 2021).

Apart from many benefits, blockchain technology has the ability to significantly increase the transparency and traceability of inventory management using smart contracts. Smart contracts are self-executed in blockchain networks, and therefore it is possible to automate many processes such as payment settlement, compliance checking, and tracing the origin of products. Their deployment eliminates the need for manual interventions and reduces errors, all of which improve accountability and make supply chain processes more efficient. Despite its many benefits, the use of blockchain technology is challenged by many issues. These include the need for many blockchain platforms to be interoperable, scalability, and data privacy (Saxena et al. 2023; Pournader et al. 2020). There is literature to suggest that blockchain technology has immense potential in changing the way inventory management is done by offering a secure, efficient platform for trading, and managing real-time data. Firms adopting technology, especially digital transformation-focused firms, have ambitious goals such as achieving operational excellence, improved risk management, and developing sustainability in supply chains.

IoT makes efficiency in inventory management via automatic and real-time tracking of inventory movement, levels, and storage conditions with networked intelligent devices and sensors. This method improves operational efficiency by connecting physical assets to digital systems to promot communication across supply chain networks (Mashayekhy et al. 2022). It is essential for accurate real-time acquisition of inventory details and stock optimization with usage of various IoT devices, such as RFID sensors, GPS tracking devices and temperature control systems, is essential for accurate real-time acquisition of inventory details and stock optimization (Ugbebor et al. 2024).IoT technology have a major impact on supply chain with providing real-time visibility and analytic capabilities. These systems provid inventory accuracy without the need for human visual inspections and risks of human mistakesand. Research shows that SMEs can achieve 25% to 35% improvement in their ability to manage inventories in real time (Ugbebor et al. 2024). In addition, IoT platforms provide accurate forecasts of future demand, automate stock replenishment processes, and minimize carrying costs with maintaining of optimal inventory levels. IoT devices also improve transparency and responsiveness across the supply chain, empowering managers to correct deviations, prevent stockouts, and maintain optimal inventory levels following Industry 4.0 requirements (Mashayekhy et al. 2022; Fang et al. 2024).

The RFID usually provides a non-guspath of tracking inventory assets in the supply chain, real-time method. Unlike barcode scanning, RFID technology allows items to read together, thus reduces manpower requirements and reduces scanning errors, which, in turn, improves their visibility. RFID enhances traceability, fast data capture and better inventory planning when there is interfex with IOT and ERP system. Research studies suggest that the use of RFID reduces inventory errors and increases the warehouse efficiency by reducing the cost -taking inventory in the long term (Saxena et al. 2023). However, the RFID implementation faces various challenges, such as high early investment in hardware, calling manufacturers to call to collect the traders between architecture or performance and heritage systems, and develop data governance framework to handle the real-time data on a large scale. Despite these challenges, the long -term benefits of RFID technology, which increase efficiency, traceability and high automation, still maintain companies in search of adopting it in more advanced digital supply chains.

Big data analytics in supply chain management has almost completely changed how companies manage inventory, respond to demand variability, and make decisions. the advantage of using big data analytics increases an organization's capability to store, process, and analyze large, complex sets of data and to strengthen strategic planning processes, and forecast accuracy (Gudavalli et al. 2022). By using historical and current data, predictive modeling and machine learning, businesses can now perform demand forecasting in advance, automate replenishment processes, and eliminate or reduce stock holding costs (Theodorakopoulos et al., 2024). For example, businesses can utilize predictive analytics to know trends and plan their inventory needs more accurately, thus reducing the risks associated with overstocks and stockouts (Anozie et al. 2024). Big data users have noted that it helps inventory planning by facilitating feasible demand. In addition, they use continuously improving adaptive algorithms that can learn from changing market trends and changing customer behavior (Singh et al. 2024). In addition, big data analytics adds sustainable inventory practices. Big data facilitates predictive maintenance and JIT practices as it matches stock levels with actual usage and helps eliminate loss and the environmental footprint loss (Skoumpopoulou et al., 2025).

These days, a combination of intelligent technologies, real -time analytics and flexible supply chain systems reconfigures inventory management systems. Techniques like IOT, Big Data and Ml are being used to strengthen the supply chain flexibility. These devices not only reduce operating costs, but also improve optimization capacity, especially in SMEs. Inventory strategies are developed to align more closely to the supply chain, a tight response to market disruption using optimal control models. Real-time data captures enhance the visibility of the captaincy inventory status, while the new forecast models will capture the data on the stocks to reduce costs and stocks against the actual demands (Fang et al., 2024; scoupsopolo et al., 2025). When AI and ML are paired with IOT devices, the real-time collection of data and analytics can make timely adjustments based on the inventory fluctuations (Kaur and light, 2025; HUERTA-SOTO et al., 2025). Big data, IOTs, and analytics give new organizational abilities to companies, which enable advanced inventory strategies to meet their goals (Fang et al., 2024; 2024; scoupsopolo et al., 2025). In addition, blockchain, AI, and IOT platform inventory management (Saxena et al., 2023) improve transparency, data integrity and automation. These technologies are creating a smart inventory system to handle complex and uncertain modern supply chains efficiently.

4. Compare Traditional and Emerging Methods in Inventory Management

This section inventory management compares the traditional and modern development of industrial purpose, functional facilities and practicality. It explains how modern computer-based solutions provide more flexibility and scalability, while traditional methods provide more stable and cost-effective approaches. In addition, it indicates the challenges and range of applying both methods. In addition, this insight supports the case for a hybrid structure that takes advantage of the complementary strength of both approaches.

4.1 Analysis of traditional and emerging inventory methods based on practical criteria

Comparison between two traditional and contemporary inventory control systems reflects a paradigm change in the way that firms react to uncertainty, scale levels and adoption of technology. Why some table 1 comparison criteria are chosen and why the performance of each system is assessed is explained in the latter paragraphs. Effectiveness refers to an inventory management system's ability to customize stock levels, cut costs and maintain service continuity. Traditional methods are marginally effective in stable, predicted environment, when demand

and lead time are consistent with simplicity and cost control (Sheikh and Raut 2020). However, their stable nature limits performance in dynamic conditions. In contrast, modern systems run by AI and ML provide high forecast accuracy and demand accountability, the order supply accuracy and inventory turnover (Fang et al. 2024; Zhao et al. 2025) significantly improve.

The adaptability assesses how well there is a good response to a system to demand ups and rapid, disruption in supply chain, or market change. Traditional systems are usually based on fixed ROP and concrete beliefs, resulting in limited adaptability (Madamidola et al. 2024). In comparison, modern systems use IOT tools and real -time data from outer variables to dynamically adjust inventory policies. For example, the AI forecast model has demonstrated high adaptability in areas with volatile demand, such as food and pharmaceuticals (Vilegas-at al. 2024; Kaur and Light, 2025). Technological integration examines how digital infrastructure connects with stock systems. Traditional methods often operate in standalone or semi integrated ERP modules, which restrict visibility and coordination (Shaikh and Raut 2020). Modern systems, however, utilize fully integrated frameworks that network inventory information throughout procurement, manufacture, and distribution. This integration is followed by technologies like RFID and blockchain, cloud platforms by improving traceability and synchronization (Theodorakopoulos et al. 2024; Saxena et al. 2023)

Implementation complexity refers to the degree of resources required to initiate and constantly operate an inventory management system. Traditional systems are identified by their simplicity often requiring just basic tools or spreadsheet structures, making them suitable for SMES (Madamidola et al. 2024). Current systems, on the other hand, are very complex due to the needs of information technology infrastructure, data governance, and staff training. However, this high complexity enables strategic advantages, such as predictive analytics and automated inventory replenishment (Zhu et al. 2024; Singh et al. 2025).

The methods used in managing inventory increasingly impact organizational sustainability goals. Traditional methods, particularly those resulting in overstocking or obsolescence, lack sufficient effectiveness towards addressing this challenge. The processes don't have effective measures that can regulate the level of inventory to reduce waste and attain the goal of lowering carbon emissions (Shaikh and Raut 2020). On the other hand, modern systems display higher effectiveness through encouraging lean inventory procedures using real-time surveillance and forward-thinking control, which, therefore, reduces overproduction and ensuing emissions (Anozie et al. 2024; Ugbebor et al. 2024).

Scalability is a system's capacity to grow in new functionalities or areas. Traditional methods are not scalable to this extent since human reconstruction is required and organization-wide activity lacks ongoing scalability (Sheikh and Raut 2020). However, because of the present inventory management system's easy scalability and modular enhancement through the use of digital technologies, businesses can copy or modify inventory procedures globally (Ugbbor et al. 2024; Theodorakopoulos et al. 2024).

Inventory management should be implemented for preventing traceability and safety, compliance with rules and increased transparency. The ERP system (Sheikh and Raut 2020) has very low record-keeping in the leigacy system based on manual records or logs. Contemporary systems use RFID and blockchain techniques to enable individual products to increase the history of transactions and secure the history of transactions. This aspect is particularly applied to high-risk, high-regulation industries such as pharmaceuticals and aerospace (Ho et al. 2021; Saxena et al. 2023). Table 1 provides a contrast of classical and contemporary models on some performance measurements associated with each inventory management method. It evaluated "high," medium, "and" low "according to several evaluation criteria.

Table 1. Compare Inventory Management Methods by Criterion

Criterion	Traditional inventory management	Modern Inventory Management
Effectiveness	Moderate	High
Adaptability	Low	High
Technological Integration	Low	High
Implementation Complexity	Low	Moderate to High
Sustainability and Environmental Impact	moderate	High
Scalability	Low	Highly
Security & Traceability	Low	High

4.2 Analysis of traditional and emerging inventory methods based on industrial applicability

The comparative analysis shows that different inventory management systems exhibit higher effectiveness in certain industries, depending on product characteristics and regulatory environment requirements. Traditional systems remain sufficiently applicable in the manufacturing and logistics sectors with predictable demand (Madamidola et al. 2024). Modern systems, on the other hand, provide great benefits to industries that require ongoing monitoring, traceability and rapid adjustments to changes in demand, due to technological advancements like blockchain technology and the Internet of Things (Ho et al. 2021; Saxena et al. 2023). The study analyzes academic papers that attempt to find suitable inventory management methods applicable to manufacturing, retail, and other industries, as shown in Table 2.

Table 2. Context-specific inventory management applicability

Application Sector	Best-Fit Traditional Methods	Best-Fit Modern Methods
Retail	EOQ, ROP	AI-based demand forecasting, IoT-enabled replenishment
Small and SMEs	EOQ, ABC	RFID, AI, if infrastructure allows
Large Enterprises	MRP	IOT, Blockchain, cloud platform
Manufacturing	MRP, EOQ	ERP-integrated predictive systems, smart sensors
Pharmaceuticals	ABC, MRP	RFID, blockchain, AI for demand prediction
Aerospace	—	Blockchain for traceability, ERP with IoT integration
healthcare	ABC	Blockchain, RFID for compliance and traceability

According to Table 2, traditional inventory methods such as EOQ, ROP, and MRP remain effective in sectors with stable demand and predictable operations, like retail and conventional manufacturing (Shaikh and Raut 2020; Madamidola et al. 2024). However, modern inventory systems that utilize AI, IoT, and blockchain are more suitable for dynamic industries such as pharmaceuticals, aerospace, perishables, and e-commerce, where real-time visibility, adaptability, and traceability are essential (Fang et al. 2024; Kaur and Prakash, 2025; Ho et al. 2021; Saxena et al. 2023). The use of these digital approaches improves forecasting accuracy, responsiveness, and regulatory compliance, overcoming traditional methods' limitations and better supporting the complexities of modern supply chains (Zhao et al. 2025; Ugbebor et al. 2024; Villegas-Ch et al. 2024).

4.3 Challenges and Limitations in Inventory Management

While there are numerous opportunities provided by new technologies, there are also challenges to the full use of such technologies. SMEs will often not have enough of paying skills, or they cannot afford them, as there might not be sufficient financial or budgetary resources, and there is not the IT infrastructure to use advanced digital solutions efficiently (Dirieh Hossein and Mohavedin, 2024). On top of that, to implement such technologies, the complexity of ERP, AI, and IoT requires trained people with the skills and experience, and increasingly, they are not easily available (Ferdosmo et al, 2024).

Another barrier to success is system integration. Many businesses continue to depend on legacy systems that cannot easily support new technologies, resulting in disconnected platforms and poor data flow (Nweje, 2025). Cultural resistance is also a consideration, as businesses may be hesitant to abandon familiar routines in favor of more complex digital processes.

To address these challenges, recent studies suggest combining both methods to improve inventory management efficiency. The research shows a high level of growth in AI and ML usage for inventory management. AI and ML are used to automate inventory replace, improve inventory levels, and support data-driven tools to make an accurate decision for managers. These tools combined with IoT, AI can support real-time tracing and predictive analytics, which make improvement in the accuracy and responsiveness of inventory systems (Kaur and Prakash, 2025; Huerta-Soto et al. 2025).When blockchain combined with artificial intelligence and the Internet of Things, it boosts up security, transparency by creating unalterable records of inventory movement and provides secure and automatic transactions thus supporting supply chain trust (Saxena et al. 2023). Furthermore, building supply chain resilience has emerged as a top priority. By leveraging big data, IoT, and advanced analytics, organizations, especially SMEs, equipe with better anticipate disruptions and comply inventory strategies with broader operational goals (Fang et al. 2024; Skoumpopoulou et al. 2025). Besides, RFID increases data capture speed, enhances traceability, and facilitates more precise inventory planning when combined with IoT and ERP systems. Therefore, a more effective inventory management system can be created by appropriately combining old techniques with digital inventory management systems.

5. Discussion and Findings

The comparative analysis of the study shows that no inventory management tool or approach is sufficient for today's volatile and expanding digital supply world. Traditional EOQ, JIT, and MRP models provide acceptable and cost-effective answers to supply shortages and demand discontinuity to the extent that supply and demand can still be considered largely predictable. Particularly with regard to tractability, analytical feasibility, and historical history of success, they can be a legitimate basis of comparisons for benchmark operations. However, their deterministic models severely limit applicability in volatile situations, especially situations in which uncertainty in demand, once a supply failure has occurred, and timely response are essential. Meanwhile, digital alternatives using AI, IoT, blockchain, or big data rely upon unprecedented real-time flexibility, decision making, and predictive ability. Parradoxically, they come with their own barriers of massive complexity, difficulties of integration with legacy applications, and especially costs of implementation. Thus, it is precisely the strength of legacy systems and the response and intelligence of digital systems that could create a logical argument for an integrated inventory management system. Such a hybrid framework would not only preserve the tried and tested qualities of conventional strategies, low expenditure, simplicity, and operating familiarity—but would also superimpose real-time feeds, automation, and predictive analysis to enhance response and resilience. Specifically, such a hybrid solution is particularly well-suited for institutions undergoing digital transformation, offering a phase-by-phase roadmap that strikes a balance between innovation and continuity of business. It is technology- and organization-friendly, especially for SMEs—and yet incrementally state-of-the-art in control of inventory. The implication is that inventory management will be more modular, more intelligent, and more adaptive, more of a problem of how to bring together disjointed systems into a strategic consolidated system than an adoption issue for technology.

Building on these findings, forthcoming investigations should attempt to verify the proposed hybrid framework of power system inventory management, including utility asset maintenance, substation's component inventory, and renewable energy integration. Discrete-event modeling and agent-based modeling can be used to experiment on real-time response and scalability of complementing EOQ and MRP frameworks and AI-powered forecasting and RFID-based asset tracking. Utilizing machine learning techniques like LSTM networks or support vector regression for forecasting failure rate and replacement cycle of transformers and intelligent grid infrastructure is proposed for researchers. Blockchain-based smart contracts can also enhance traceability and conformity of handling critical power infrastructure inventory, possibly coupled with ABC classification for determining high-value items and safety-critical items. These avenues are promising starting points for developing resilient and adaptive policies for managing inventory under operational realities and reliability expectations for next-generation power grids.

6. Conclusion

This study provides a comprehensive analysis of inventory management approaches by combining proven models such as EOQ, JIT, and MRP with emerging digital technologies like AI, IoT, RFID, and blockchain. This paper, through a systematic literature review, comparative assessment, and focused sectoral analysis, has completely addressed all mentioned research objectives. The study compared the benefits and limitations associated with every paradigm, besides the rising needs for an integrative approach that recognizes the dynamic character of supply chains. The key contribution of this study is the development of a hybrid inventory management system that takes advantage of the cost-effectiveness and structural reliability inherent in traditional models and as well as exploits the capabilities of intelligence and real-time reactivity that modern technologies offer. This hybrid model offers a strategic path for gradual digital transformation, particularly suited to small and medium-sized enterprises that face resource and infrastructure constraints. The important knowledge gap filled by this study regards the disjuncture between current literature, which often makes separate distinctions between traditional methods and new technology. Several previous studies reflect an affinity for concentrating on either traditional framework only or advanced technologies exclusively, hence omitting to provide an integrated perspective that captures transitional dynamics between these two paradigms. Additionally, most current evaluations suggest functional, integrative models only in passing and consider such factors like readiness of an industry, scalability, and operational constraints. Integrating traditional and digital elements into an overarching, context-aware framework, an article herein presents an original contribution bridging theory and reality. Future research should seek to verify the framework by empirical studies and computer-based modeling across multiple industries to assess its viability and impact on real-world operating environments.

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