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Inventory management practices and supply chain efficiency: Insights from modern techniques

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Abstract

Inventory management is a critical component of supply chain efficiency, directly influencing cost reduction, customer satisfaction, and operational flexibility. The primary objective of this study is to evaluate how modern inventory management practices particularly Vendor Managed Inventory (VMI), Just-in-Time (JIT), and Economic Order Quantity (EOQ) contribute to improving supply chain performance. The methodology is based on secondary research, industry reports, and real-world case studies. The approach highlights different inventory management practices and their impact on supply chain efficiency. Inventory management is not limited to cost control but it also plays a key role in making a supply chain stronger and more competitive. Organizations that adopt advanced inventory management systems and tools achieve higher efficiency, better integration, and long-term sustainability.

The results demonstrate that efficient inventory control minimizes stockouts, guarantees optimal resource utilization, and lowers holding and ordering costs. Methods like VMI enhance supplier-buyer collaboration, JIT reduce lead times and wastage, and EOQ provide a systematic approach to balancing supply and demand. When used together, these methods make supply and demand more balanced, improve overall efficiency and keep the whole supply chain better connected. The findings suggest that investment in inventory technologies and forecasting models is essential to building resilient supply chains.

Keywords: Inventory Optimization, VMI, JIT, EOQ, Demand Forecasting, Stockouts Reduction

1. Introduction

In today's competitive business environment, companies compete not just individually but as part of broader supply chains ^[1, 5]. An efficient supply chain ensures the smooth flow of materials, information, and finances from suppliers to customers. Within this system, inventory management is crucial. It ensures that the right quantity of goods is available at the right time, preventing stock out, excess inventory, and production delays ^[3, 4]. Therefore, inventory management is not only an operational function but also a strategic tool that enhances supply chain efficiency by reducing costs, optimizing processes, and improving customer satisfaction.

When too much money gets tied up in inventory, it can lead to delays in production, higher storage costs, or even shortages that disappoint customers ^[3, 4]. All these issues make the supply chain weaker. On the other hand, managing inventory properly helps use resources efficiently, improves coordination among partners, and ensures customers get what they need on time, making the entire supply chain stronger ^[1, 5].

The role of inventory management in improving supply chain efficiency can be explained through several key aspects. First, it helps control costs by balancing expenses related to storing, ordering, stock out costs directly improve financial performance ^[3, 4]. Second, it encourages best practices, such as accurate demand forecasting, strong collaboration with suppliers, and regular inventory checks, which make the supply chain more flexible ^[5, 8]. Effective inventory management ensures smooth operations, reduces delays, and keeps customers satisfied by making sure the right products are available at the right time ^[1].

2. Historical Background

Inventory management has always been a crucial aspect of organizational performance and directly linked to the efficiency of supply chains ^[1, 5].

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Historically, both profit-oriented businesses and non-profit institutions such as hospitals, universities, temples, and government offices have faced similar issues like stock shortages, excess inventory, and wastage challenges ^[4]. These challenges affect not only the organization but also the wider supply chain, leading to delays, increased costs, and disruptions in the flow of goods.

Before the 20th century, inventory management lacked a scientific foundation. Most decisions were based on intuition, past experience, or simple estimation ^[1, 4]. This error approach often caused mismatches between supply and demand, resulting in production delays, high storage costs, or failure to meet customer needs. These inefficiencies affected the entire supply chain, slowing the movement of materials, disrupting production schedules, and reducing the ability to respond quickly to market demands.

After World War II, industries began to realize how important it was to manage risk and uncertainty in inventory ^[4]. Shortages or excess stock were no longer viewed as isolated issues. They could disrupt the entire supply chain. By adopting risk oriented inventory strategies, organizations were able to maintain smoother operations, stabilized material flow, and enhanced supply chains stability, which was especially crucial during a time of economic uncertainty ^[1, 5].

Later, modern techniques such as Just-in-Time (JIT) and Vendor Managed Inventory (VMI) have transformed the way inventory is managed ^[2, 4]. JIT helped reduce lead times and cut down on waste, allowing supply chains to respond more quickly and flexibly to changes in demand. JIT helped reduce lead times and cut down on waste, allowing supply chains to respond more quickly and flexibly to changes in demand ^[2]. VMI encouraged closer collaboration between suppliers and buyers by giving suppliers the responsibility for managing stock ^[5, 6]. (EOQ) is applied only when demand is certain, it is optimal, provide a systematic approach to balancing demand with supply ^[1, 3]. This improved coordination, reduced inefficiencies, and made supply chains run more smoothly. Together, these techniques shifted inventory management from being just a cost-related task to a strategic tool that strengthens supply chain performance.

3. Literature Review

Inventory management has been consistently discussed as a critical factor in improving supply chain efficiency because it directly influences cost, lead time, and customer service ^[1, 4]. A well-managed inventory system not only avoids wastage and stock outs but also ensures smoother material flow across the supply chain.

The earliest systematic contribution came from Harris in 1913 through the Economic Order Quantity (EOQ) model ^[1, 3]. His work explained how companies can achieve cost efficiency by balancing ordering costs and holding costs. By applying EOQ, firms were able to avoid overstocking, which ties up capital, and understocking, which causes delays ^[1, 3]. This connection between inventory planning and cost optimization was one of the first to show how inventory management directly improves supply chain performance.

Later studies highlighted that inventory costs are not just limited to storage but also include transportation, handling, and even the cost of shortages ^[5]. Controlling these costs plays a major role in supply chain competitiveness. Researchers have shown that efficient inventory policies can

reduce total logistics expenses and increase profitability while still meeting customer expectations ^[5].

During the 1970s, the Just-in-Time (JIT) approach introduced by Toyota focused on reducing waste and unnecessary stock ^[2]. JIT emphasized producing and delivering goods only when needed, which lowered carrying costs and improved responsiveness. At the same time, scholars noted that such lean practices require highly reliable supply networks, as any disruption could lead to significant losses due to minimal safety stock ^[2, 10].

In the 1990s, the concept of Vendor Managed Inventory (VMI) brought attention to collaboration in cost control ^[5, 6]. By allowing suppliers to manage replenishment, companies benefited from reduced stockouts, lower carrying costs, and better alignment of supply with demand. VMI literature highlighted that cost efficiency in supply chains is not only achieved internally but also through stronger supplier-buyer coordination.

In recent years, the focus has shifted toward digital and data-driven inventory systems ^[8]. Tools such as ERP software, predictive analytics, and artificial intelligence have helped firms forecast demand more accurately and reduce excess stock ^[8]. This not only minimizes overall inventory costs but also improves service levels and makes supply chains more resilient. Some recent studies also connect efficient inventory management with sustainability, as reducing waste and optimizing stock contributes to greener and more cost-effective supply chains.

4. Impact of Inventory costs on supply chain performance

Inventory is more than just stored products; it is a strategic tool that drives the performance of the entire supply chain ^[1, 5]. How a company manages its inventory costs directly affects the speed of product flow, the ability to meet customer demand, and the overall efficiency of operations from suppliers to end customers ^[1, 3, 5]. When managed well, inventory costs become levers to enhance supply chain efficiency, rather than obstacles that create delays or bottlenecks.

4.1 Ordering Costs

Ordering costs include administrative work, communication with suppliers, and inspection of incoming goods ^[3]. When ordering costs are high, companies often purchase in large batches, increasing storage needs and slowing product movement. By reducing these costs through efficient procurement systems and close supplier coordination, organizations can place smaller, more frequent orders ^[5]. This ensures a steady flow of products, avoids overstocking, and allows the supply chain to respond quickly to changing customer demand.

Example: Walmart's Retail Link system shares real-time inventory and sales data with suppliers, allowing timely replenishment and smooth product flow throughout the supply chain ^[6, 9].

4.2 Optimal Inventory Costs

Optimal inventory cost represents the point at which total inventory-related expenses ordering, holding, and stockouts are minimized while the supply chain remains highly responsive ^[1, 3, 5]. Maintaining inventory at this level ensures that capital is not unnecessarily tied up and products are available exactly when needed, enhancing agility,

responsiveness, and overall efficiency.

Example: Toyota's Just-In-Time (JIT) system keeps inventory at optimal levels, reducing excess stock while maintaining smooth production and supply chain continuity [2, 10].

4.3 Holding (Carrying) Costs

Holding costs cover warehousing, utilities, insurance, and the opportunity cost of capital invested in inventory [3]. Excessive holding costs make the supply chain rigid, as resources remain tied up instead of being available for responsive operations. Reducing holding costs through faster inventory turnover and accurate forecasting keeps the supply chain flexible, efficient, and capable of meeting demand promptly [5, 8].

Example: Toyota's JIT approach ensures materials arrive only when needed, lowering holding costs and enabling continuous product flow from suppliers to production lines [2].

4.4 Stock-out Costs

Stockouts disrupt the supply chain, leading to lost sales, backorders, and reduced customer satisfaction [5]. Effective inventory management minimizes stockout risks by maintaining appropriate safety stock and improving forecasting. This ensures continuous availability of products, enhancing the reliability and resilience of the supply chain.

Example: Walmart's Vendor-Managed Inventory (VMI) allows suppliers to proactively replenish stores, keeping products moving without interruption [6, 9].

4.5 Setup and Changeover Costs

High setup costs for switching production between products often lead to large batch production, increasing inventory and slowing down the supply chain [3]. Reducing setup costs enables smaller, flexible production runs, maintaining balanced inventory levels and smooth movement of products throughout the supply chain.

Example: Toyota optimizes setup times so components and finished products flow seamlessly, supporting continuous and efficient supply chain operations [10].

4.6 Transportation Costs

Transportation costs impact how efficiently products move from suppliers to warehouses and ultimately to customers [5]. Optimizing shipment sizes and routes ensures timely delivery without excess cost, keeping the supply chain fast, reliable, and responsive.

Example: Walmart uses cross-docking and route optimization to reduce transportation expenses while ensuring products move quickly from distribution centers to stores.

4.7 Obsolescence and Shrinkage Costs

Obsolescence occurs when products lose value over time, while shrinkage results from theft, loss, or errors [1, 3]. Poorly managed inventory amplifies these risks, slowing supply chain performance. Aligning inventory with demand ensures efficient product flow, minimal waste, and quick adaptation to market changes.

Example: Toyota's JIT system prevents excess inventory, reducing obsolescence and maintaining smooth production

and distribution flow [11].

4.8 Capital Costs

Inventory ties up capital that could otherwise be invested in improving supply chain technology, expanding capacity, or enhancing logistics [1, 5]. High capital costs limit flexibility and responsiveness. Efficient inventory management frees resources, allowing investment in systems and processes that strengthen supply chain efficiency and agility.

Integrated Insight

Each type of inventory cost ordering, holding, stockouts, setup, transportation, obsolescence, and capital directly impacts the speed, reliability, and adaptability of the supply chain [5]. Mismanaged costs create bottlenecks, delays, and inefficiencies, whereas optimized costs ensure products flow smoothly, resources are used effectively, and the supply chain can respond promptly to demand changes.

Example: Walmart optimizes ordering, stockout, and transportation costs to maintain a responsive supply chain, while Toyota minimizes holding, setup, and obsolescence costs through JIT and Kanban, ensuring continuous, efficient product flow [6, 9].

5. Demand Forecasting

Inventory is only truly valuable when it is available at the right time and in the right quantity. Demand forecasting allows companies to anticipate customer needs and plan their stock accordingly [8]. When done correctly, it turns inventory from a passive store of goods into a strategic tool that actively improves supply chain efficiency.

Accurate forecasting helps organizations maintain optimal inventory levels enough to meet customer demand without overstocking. This balance ensures capital isn't unnecessarily tied up, reduces storage costs, and frees resources to strengthen other parts of the supply chain [5, 8].

It also prevents stockouts, keeping products moving smoothly from suppliers to warehouses to customers. By predicting demand, companies can schedule orders more precisely, reducing administrative effort and avoiding delays, which makes the supply chain more responsive and reliable [8].

Real-world examples

Toyota schedules its production based on anticipated demand, ensuring that materials arrive just in time [2, 7]. This keeps production flowing smoothly, lowers holding costs, and prevents excess inventory from building up.

FMCG companies often use forecasting to balance stock across multiple warehouses [8]. This ensures that popular items are always available where they are needed, while avoiding overstock that could tie up capital or risk obsolescence.

In short, demand forecasting turns inventory management into a proactive strategy. By anticipating customer needs, businesses can ensure that the supply chain remains agile, cost-effective, and capable of delivering products efficiently [5, 8]. Inventory becomes a lever for improving supply chain speed, responsiveness, and overall performance.

6. Best practices for supply chain efficiency through inventory management

Effective supply chain efficiency depends not only on inventory techniques but also on the adoption of best

practices that ensure accuracy and collaboration ^[1, 5]. These practices allow organizations to align inventory policies with the overall objectives of the supply chain. By doing so, businesses can reduce unnecessary costs, improve responsiveness, and deliver better service to customers.

6.1 Accurate Forecasting

Reliable demand forecasting ensures that products are available when needed without creating excess stock ^[8]. This directly prevents delays, stockouts, and overstocking, which are major inefficiencies in supply chains. Accurate forecasting aligns purchasing, production, and distribution, leading to smoother supply chain operations.

6.2 Supplier Collaboration

Strong partnerships with suppliers enhance information sharing, reduce uncertainty, and align supply with actual demand. This reduces demand fluctuations and ensures that supply chain members from raw material suppliers to retailers work together efficiently ^[5, 6, 9].

6.3 Cross-functional Collaboration

Inventory management does not operate in isolation. Coordination between sales, operations, finance, and logistics ensures that decisions are consistent across departments ^[1, 5]. This holistic approach eliminates bottlenecks and enables the supply chain to function as a unified system.

6.4 Regular Audits

Auditing stock records maintains accuracy and reduces shrinkage or errors. This practice ensures transparency and reliability across the supply chain, enabling better planning and reducing risks of mis-shipments, losses, or inefficiencies.

7. Impact of Inventory System on Supply Chain

Inventory management relies heavily on the system used to record, track, and update stock levels ^[1, 5]. Two widely recognized systems are the Periodic Inventory System and the Perpetual Inventory System, both of which have distinct implications for supply chain efficiency.

7.1 Periodic Inventory System

It updates stock records at specific intervals, such as weekly or monthly ^[1]. While this method is simple and less costly, it often results in outdated information about stock levels. In a dynamic supply chain, this can lead to delays in replenishment, higher chances of stockouts, or excess inventory ^[6]. As a result, efficiency is compromised since decisions are based on estimates rather than real-time data ^[9].

7.2 Perpetual Inventory System

It continuously updates inventory records through technologies like barcoding or integrated ERP systems. This approach allows managers to have real-time visibility of stock levels, which directly improves forecasting, reduces safety stock, and minimizes lead times ^[5, 8]. By ensuring that the right products are available when needed, the perpetual system strengthens coordination across suppliers, manufacturers, and distributors, ultimately enhancing supply chain efficiency.

In today's competitive environment, most organizations are

shifting from periodic to perpetual systems because supply chain efficiency now depends on accurate, timely, and technology-driven information. This shift not only reduces costs but also enables companies to respond quickly to changing customer demand, making the entire supply chain more agile and reliable ^[2, 7, 10].

8. Case Study

8.1 Walmart-The Pioneer of Supply Chain Excellence

Walmart, the world's largest retailer, is often regarded as a benchmark in supply chain management and inventory practices ^[6, 9]. Its philosophy of Everyday Low Prices has been achieved not only through aggressive pricing strategies but also through the intelligent use of inventory as a strategic asset. Walmart transformed it into a vital resource for achieving efficiency, lowering costs, and driving customer satisfaction.

A central pillar of Walmart's inventory management strategy is its adoption of vendor managed inventory (VMI) ^[9]. Under VMI, suppliers themselves monitor and replenish Walmart's stock levels at both distribution centers and stores, thereby reducing the risks of both stock-outs and overstocking.

Technology integration has played a transformative role in Walmart's inventory practices. Early on, the company adopted information technologies such as Radio Frequency Identification (RFID) tags to track products in real time across the entire supply chain ^[6, 9]. Its proprietary Retail Link system provided suppliers with direct access to Walmart's sales and inventory data, enabling accurate forecasting and efficient replenishment decisions. By creating visibility across all tiers of the supply chain, Walmart enhanced coordination, reduced uncertainties, and improved its ability to meet customer demand consistently ^[9].

The outcomes of these practices have been substantial. Walmart's supply chain has enabled it to maintain lower operating costs, which directly supports its promise of low prices to customers. Store shelves are rarely empty, thereby enhancing customer satisfaction and loyalty ^[9]. Moreover, the scalability of its supply chain has allowed Walmart to replicate its model across diverse geographies and markets. While critics argue that Walmart's system exerts immense cost pressure on its suppliers, there is little doubt that the company's success demonstrates how inventory management can form the backbone of supply chain excellence ^[5, 9].

8.2 Toyota-The Lean Manufacturing Icon

Toyota, the Japanese automotive giant, revolutionized supply chain management through its Toyota Production System (TPS) ^[2, 7]. Globally recognized as the gold standard for lean manufacturing, TPS emphasizes waste reduction, process efficiency, and continuous improvement known in Japanese as *Kaizen*. Central to this system is Toyota's pioneering use of the Just-In-Time (JIT) philosophy, which redefined how companies worldwide perceive inventory ^[2, 10, 11].

The Just in Time approach ensures that materials and components arrive exactly when required in the production process, rather than being stored in large volumes ^[2, 7]. This principle of produce only what is needed, when it is needed, and in the amount needed allowed Toyota to minimize holding costs, reduce waste, and improve efficiency.

Complementing JIT, The Kanban system uses visual signals to show when inventory needs to be restocked, helping keep production and supplies flowing smoothly ^[10, 11]. Kanban cards acted as simple yet effective indicators of when and how much inventory should be supplied, creating a smooth and synchronized production flow while preventing overproduction or bottlenecks ^[10].

Toyota's approach to inventory management extended beyond internal operations to encompass deep collaboration with its suppliers. Through its keiretsu system of long term partnerships, suppliers were treated as strategic allies rather than transactional vendors ^[7]. These partners gained access to Toyota's demand forecasts and production schedules, aligning their operations closely with Toyota's needs. This level of trust and collaboration not only ensured timely availability of materials but also promoted innovation and quality improvements across the supply chain ^[2, 7].

The results of Toyota's inventory practices were remarkable. The company achieved consistently high inventory turnover and improved quality levels because defects were identified and corrected immediately within the JIT system ^[2, 7]. However, crises such as the 2011 tsunami and the COVID-19 pandemic highlighted vulnerabilities within the lean JIT model, as global disruptions exposed its fragility. Toyota showed its flexibility by adding backup suppliers and improving the visibility of its supply chain. This made it clear that inventory management is not just about cutting costs, but also about building a culture of agility and resilience within the organization.

9. Comparative Insights

A comparison between Walmart and Toyota illustrates how different approaches to inventory management can produce equally successful yet distinct outcomes ^[5-7]. Walmart focuses on scale, technology, and cost leadership by implementing systems like vendor-managed inventory, reinforced with digital tools such as RFID and Retail Link ^[6, 9]. On the other hand, Toyota emphasizes waste elimination, quality, and efficiency through its Just in Time and Kanban models, supported by long-term supplier relationships within the keiretsu framework ^[2, 10, 11].

Although both companies differ in their objectives Walmart targeting cost efficiency and availability, while Toyota pursues quality and lean operations the underlying insight remains the same: inventory is not a passive stockpile but a strategic driver of competitiveness. Where Walmart demonstrates how inventory practices can enable low-cost retailing on a massive global scale, Toyota proves that inventory management can serve as the foundation of a culture rooted in continuous improvement and operational excellence ^[2, 7, 10]. Together, these cases underline the central role of inventory management in shaping supply chain success stories.

10. Conclusion

Inventory management plays a key role in making supply chains efficient and reliable. This study shows that practices like Just-In-Time (JIT), Vendor Managed Inventory (VMI), accurate demand forecasting, and the use of better inventory systems help reduce costs, avoid stockouts, and improve coordination between different parts of the supply chain. Over time, inventory management has changed from being just about storage to becoming a strategic tool that improves competitiveness and flexibility.

The examples of Walmart and Toyota clearly show how different methods can still lead to success. Walmart uses technology and supplier-managed systems to keep products available at low cost, while Toyota focuses on lean practices like JIT and Kanban to reduce waste and maintain smooth operations. Both prove that strong inventory management can build supply chains that are efficient, responsive, and customer focused.

In today's fast-changing market, companies that adopt forecasting, collaboration, and modern inventory systems will be better prepared for challenges. Proper inventory management not only improves efficiency but also ensures long-term sustainability and success of the supply chain.

11. Conflicts of Interest Declaration

The authors hereby declare that there are no known financial, personal, or professional conflicts of interest that could have appeared to influence the work reported in this paper. The research was conducted independently, without any external influence or funding from commercial, political, or institutional sources that may stand to benefit from its findings.

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