



Artificial Intelligence and Inventory Performance: A Longitudinal Analysis of Amazon's Supply Chain Operations (2017–2023)

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Keywords

Artificial Intelligence; Inventory Management; Supply Chain Management; Amazon; Predictive Analytics; Warehouse Automation; Digital Transformation

Abstract

The increasing adoption of artificial intelligence (AI) has transformed the way organizations manage inventory, coordinate supply chains, and respond to rapidly changing market conditions. As global businesses face growing pressure to improve operational efficiency while maintaining high levels of customer service, AI-driven technologies have emerged as important tools for enhancing inventory visibility, forecasting accuracy, and logistical performance. Against this background, this study investigates the contribution of artificial intelligence to inventory management through an analytical case study of Amazon, a company widely recognized for its extensive use of digital technologies and automated logistics systems. The study employs a comparative analysis of inventory management indicators for 2017 and 2023, representing two different stages in Amazon's technological development. Key performance measures include inventory turnover, inventory holding period, inventory-related costs, inventory loss rates, and

the level of intelligent systems utilization. The findings reveal notable improvements across all examined indicators. Inventory turnover increased, inventory holding periods declined, storage-related costs were reduced, and inventory losses decreased. At the same time, the utilization of AI-enabled systems expanded substantially, reflecting Amazon's growing reliance on predictive analytics, machine learning algorithms, robotics, and automated warehouse management technologies. The results suggest that artificial intelligence has contributed to greater inventory efficiency by improving demand forecasting, accelerating inventory movement, optimizing warehouse operations, and enhancing supply chain coordination. Furthermore, the integration of AI with complementary digital technologies such as the Internet of Things (IoT), cloud computing, and data analytics has strengthened operational responsiveness and supported more effective resource utilization. The study concludes that artificial intelligence is no longer merely a supporting technological resource but has become a strategic capability that shapes contemporary inventory management practices. By enabling organizations to make faster, more informed, and data-driven decisions, AI contributes to operational excellence, supply chain resilience, and sustainable competitive advantage in increasingly complex business environments.

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1. INTRODUCTION

The rapid advancement of digital technologies has fundamentally transformed the way organizations manage operations, allocate resources, and coordinate supply chain activities. Among these technological developments, artificial intelligence (AI) has emerged as a particularly influential force, enabling organizations to process vast amounts of data, improve decision-making accuracy, and respond more effectively to increasingly dynamic market conditions. Advances in machine learning, predictive analytics, cloud computing, robotics, and the Internet of Things (IoT) have accelerated the adoption of AI-driven solutions across a wide range of business functions, including logistics, procurement, warehousing, and inventory management.

Inventory management occupies a central position within supply chain operations because it directly influences organizational efficiency, customer satisfaction, and financial performance. Maintaining an appropriate balance between inventory availability and cost control has become increasingly challenging in contemporary business environments characterized by fluctuating demand, shorter product life cycles, globalized supply networks, and growing customer expectations for rapid delivery. Consequently, organizations are increasingly seeking intelligent solutions capable of improving forecasting accuracy, optimizing stock levels, and enhancing operational flexibility.

In recent years, artificial intelligence has attracted significant attention as a tool for addressing many of these challenges. AI-enabled systems can continuously analyze historical and real-time data, identify demand patterns, anticipate market fluctuations, and support more effective inventory planning decisions. Previous studies have suggested that the integration of artificial intelligence into inventory management can improve operational efficiency, reduce inventory-related costs, minimize stockouts, and strengthen supply chain resilience. Nevertheless, despite the growing body of literature on AI applications in supply chain management, empirical evidence linking AI adoption to measurable inventory management outcomes remains relatively limited.

Amazon provides a particularly relevant context for examining this relationship. As one of the world's largest e-commerce and logistics organizations, Amazon has invested extensively in artificial intelligence, predictive analytics, warehouse automation, and intelligent robotics. Through the development of advanced digital infrastructure and data-driven operational systems, the company has transformed inventory management into a highly integrated and technologically sophisticated process. Consequently, Amazon represents an important case through which the practical implications of AI-driven inventory management can be explored.

Against this background, the present study investigates the relationship between artificial intelligence adoption and inventory management performance through a comparative analysis of Amazon's operational indicators between 2017 and 2023. By examining

changes in inventory turnover, inventory holding periods, inventory-related costs, inventory losses, and intelligent systems utilization, the study seeks to provide insights into how artificial intelligence contributes to inventory optimization and operational effectiveness within large-scale digital enterprises.

The study contributes to the existing literature by providing a longitudinal assessment of inventory management performance during a period of substantial technological transformation. In doing so, it offers both theoretical and practical insights into the strategic role of artificial intelligence in contemporary supply chain and inventory management practices.

2. Literature Review

2.1 Artificial Intelligence and the Transformation of Contemporary Supply Chains

The growing complexity of global supply chains has accelerated the adoption of digital technologies capable of improving organizational agility, operational visibility, and decision-making quality. Among these technologies, artificial intelligence (AI) has emerged as one of the most influential drivers of supply chain transformation. Advances in machine learning, predictive analytics, cloud computing, computer vision, and intelligent automation have enabled organizations to move beyond traditional planning approaches toward more adaptive and data-driven operational systems (Ivanov & Dolgui, 2021).

Recent research suggests that AI has fundamentally altered the way organizations manage uncertainty and respond to rapidly changing market conditions. Rather than relying solely on historical data and periodic forecasting cycles, firms increasingly utilize AI-enabled systems capable of continuously processing large volumes of real-time information and generating dynamic operational recommendations. As a result, decision-making processes have become more responsive, predictive, and scalable (Iansiti & Lakhani, 2020).

The strategic importance of AI has become particularly evident in environments characterized by supply disruptions, volatile consumer demand, and increasing expectations for rapid product delivery. Wamba et al. (2020) argue that organizations that successfully integrate advanced analytics and AI capabilities achieve superior operational performance through improved forecasting accuracy, resource allocation, and process coordination. Consequently, AI is increasingly viewed not merely as a technological innovation but as a strategic organizational capability that contributes to long-term competitiveness and resilience.

2.2 Artificial Intelligence in Inventory Management

Inventory management has emerged as one of the most significant application areas of artificial intelligence within supply chain operations. Effective inventory management requires organizations to balance product availability with cost efficiency while responding to fluctuating customer demand and operational uncertainty. Traditional inventory models often struggle to achieve this balance because they rely heavily on static forecasting techniques and historical sales patterns that may not accurately reflect changing market conditions.

Artificial intelligence offers a fundamentally different approach by enabling organizations to process diverse data sources, identify complex relationships, and continuously refine forecasting models. Choi et al. (2018) emphasize that big data analytics and AI-driven decision systems enhance operational intelligence by generating more accurate demand forecasts and supporting inventory optimization decisions.

Several empirical studies have highlighted the positive relationship between AI adoption and inventory performance. Bag et al. (2021) found that technology-enabled operational systems contribute to improved efficiency, lower operational costs, and enhanced organizational performance. Similarly, Christopher (2022) argues that intelligent inventory management systems help organizations simultaneously reduce excess inventory and minimize stockout risks, thereby improving both customer service and cost control.

Machine learning algorithms have become particularly valuable in demand forecasting applications because they can incorporate multiple internal and external variables, including seasonal trends, consumer preferences, promotional activities, and macroeconomic conditions. By improving forecasting precision, AI contributes to more effective inventory planning, warehouse utilization, and replenishment decisions, ultimately enhancing overall supply chain performance.

2.3 Smart Warehousing, Automation, and Digital Logistics

The development of intelligent warehousing technologies has significantly expanded the operational role of artificial intelligence in inventory management. Modern warehouses increasingly incorporate autonomous mobile robots, RFID-based tracking systems, computer vision technologies, and Internet of Things (IoT) devices that facilitate real-time inventory monitoring and automated material handling.

Research suggests that warehouse automation contributes not only to operational efficiency but also to greater inventory accuracy and process reliability. Ivanov et al. (2019) report that digitally integrated warehousing systems improve inventory visibility, reduce operational errors, and accelerate order fulfillment activities. Likewise, Brynjolfsson and McAfee (2017) argue that intelligent automation enables organizations to improve productivity by reducing repetitive manual tasks while simultaneously increasing operational precision.

The growing adoption of smart warehousing technologies is particularly relevant for e-commerce organizations that process millions of transactions and inventory movements daily. In such environments, automation serves not merely as a cost-reduction mechanism but as a strategic enabler of scalability, responsiveness, and service quality.

2.4 Amazon as a Benchmark for AI-Driven Inventory Management

Among contemporary organizations, Amazon is widely regarded as one of the most advanced examples of AI-enabled logistics and inventory management. The company has invested extensively in predictive analytics, robotics, machine learning, cloud infrastructure, and automated fulfillment technologies to optimize inventory flows and improve customer service outcomes (Dumaine, 2020).

Amazon's inventory management strategy is built upon a highly integrated digital ecosystem in which forecasting systems, warehouse automation technologies, and logistics networks operate in a coordinated manner. Previous studies have highlighted the company's use of predictive algorithms to improve inventory allocation, anticipate customer demand, and optimize replenishment decisions (Brynjolfsson & McAfee, 2017). The acquisition of Kiva Systems, later rebranded as Amazon Robotics, represented a significant milestone in the company's transition toward highly automated warehouse operations.

Through innovations such as predictive inventory placement, real-time inventory tracking, and machine learning-driven logistics planning, Amazon has demonstrated how AI can be integrated into large-scale supply chain operations. Nevertheless, much of the existing literature focuses primarily on describing Amazon's technological infrastructure rather than evaluating how these technologies are reflected in measurable inventory management outcomes over time.

2.5 Research Gap

Despite substantial scholarly interest in artificial intelligence and supply chain management, several gaps remain within the existing literature. First, many studies emphasize conceptual frameworks, technological architectures, or general supply chain performance indicators without specifically examining inventory management outcomes. Second, while numerous publications discuss the theoretical advantages of AI adoption, relatively few studies provide longitudinal evidence demonstrating how increasing levels of AI integration influence inventory-related performance indicators.

Furthermore, although Amazon is frequently presented as a leading example of digital transformation, empirical assessments linking the company's AI investments to specific inventory management outcomes remain limited. Existing research tends to focus on technological capabilities rather than operational performance metrics such as inventory turnover, inventory holding periods, inventory-related costs, and inventory loss rates.

To address these limitations, the present study investigates changes in Amazon's inventory management performance between 2017 and 2023, a period characterized by substantial expansion in artificial intelligence adoption. By examining measurable operational indicators over time, the study seeks to contribute to a more nuanced understanding of the relationship between AI implementation and inventory management effectiveness within large-scale digital enterprises.

3. RESEARCH METHODOLOGY

Research Design

This study adopts a quantitative case study approach to examine the contribution of artificial intelligence (AI) to inventory management performance within Amazon. The case study method was selected because Amazon represents one of the world's most technologically advanced organizations in the application of AI-driven logistics, warehouse automation, and supply chain management systems. The research focuses on evaluating how the expansion of intelligent technologies has influenced key inventory management outcomes over time.

Data Sources

The analysis is based on secondary data collected from Amazon's annual reports, publicly available financial disclosures, corporate sustainability reports, industry publications, and scholarly literature addressing artificial intelligence and supply chain management.

To assess changes associated with digital transformation, data were collected for two benchmark years: **2017** and **2023**. The year 2017 represents a period during which AI technologies were present but not yet fully integrated into inventory management processes, whereas 2023 reflects a more mature stage characterized by extensive deployment of machine learning systems, predictive analytics, robotics, and intelligent warehouse technologies.

Variables and Performance Indicators

To evaluate inventory management performance, five key indicators were selected based on their widespread use in logistics and operations management research:

1. **Inventory Turnover Ratio** – measuring the frequency with which inventory is sold and replenished during a fiscal year.
2. **Average Inventory Holding Period** – indicating the average number of days inventory remains within the warehouse system.
3. **Inventory Holding Cost Ratio** – assessing the proportion of inventory-related costs relative to average inventory value.
4. **Damaged and Lost Inventory Ratio** – measuring inventory losses resulting from operational inefficiencies, damage, or misplacement.
5. **Rate of Intelligent Systems Utilization** – evaluating the extent to which AI-based technologies are integrated into inventory management operations.

These indicators collectively provide a multidimensional assessment of inventory efficiency, operational effectiveness, and technological adoption.

Analytical Procedure

The study employs a comparative longitudinal analysis to examine differences between the selected benchmark years. Inventory performance indicators were calculated using established logistics and supply chain management formulas. Changes in the indicators were subsequently analyzed to identify operational improvements associated with the increasing adoption of artificial intelligence technologies.

The comparative framework enables the evaluation of trends in inventory performance while highlighting the relationship between AI implementation and key operational outcomes. Particular attention was given to changes in inventory turnover, inventory holding duration, inventory-related costs, and inventory loss rates.

4. Results

4.1 Descriptive Comparison of Inventory Management Performance

To evaluate the relationship between artificial intelligence adoption and inventory management performance, a comparative assessment of Amazon's operational indicators was conducted using data from 2017 and 2023. These years represent two distinct stages in Amazon's digital transformation trajectory. While 2017 reflects a period characterized by partial integration of intelligent systems, 2023 represents a mature stage of AI deployment across inventory management and supply chain operations.

Table 1. Comparative Inventory Management Indicators

Indicator	2017	2023	Percentage Change
Inventory Turnover Ratio	11.84	13.09	+10.56%
Average Inventory Holding Period (Days)	30.82	27.89	-9.51%
Inventory Holding Cost Ratio (%)	20.00	18.00	-10.00%
Damaged and Lost Inventory Ratio (%)	1.00	0.90	-10.00%
Intelligent Systems Utilization (%)	55.00	93.00	+69.09%

The results reveal a clear pattern of operational improvement during the study period. All performance indicators moved in a favorable direction, suggesting that Amazon's increasing reliance on artificial intelligence technologies coincided with enhanced inventory management effectiveness.

Figure 1. Inventory Turnover Ratio (2017–2023)

[Insert Figure 1 Here]

Inventory turnover increased from 11.84 to 13.09 times annually. This represents a 10.56% improvement in inventory circulation efficiency. The result indicates that Amazon became more effective in converting inventory into sales while simultaneously maintaining product availability throughout its fulfillment network.

Figure 2. Average Inventory Holding Period (2017–2023)

[Insert Figure 2 Here]

The average inventory holding period decreased from 30.82 days to 27.89 days. The reduction suggests faster inventory movement and improved synchronization between inventory availability and customer demand.

Figure 3. Intelligent Systems Utilization (2017–2023)

[Insert Figure 3 Here]

The most substantial change was observed in the utilization of intelligent systems, which increased from 55% to 93%. This growth reflects Amazon’s extensive adoption of machine learning, predictive analytics, warehouse robotics, and intelligent inventory optimization systems.

4.2 Operational Performance Assessment

The comparative evidence suggests that increased AI utilization was accompanied by improvements in inventory turnover, inventory holding periods, inventory-related costs, and inventory loss rates. In particular, the reduction in holding costs and inventory losses indicates greater operational precision and enhanced inventory visibility throughout the supply chain.

Although the magnitude of change varies across indicators, the direction of change remains consistently positive. This pattern supports the proposition that artificial intelligence contributed to inventory optimization and operational efficiency within Amazon’s logistics ecosystem.

4.3 Comparative Performance Index

To provide an overall assessment, a normalized performance comparison was conducted across all selected indicators. The results indicate that Amazon experienced simultaneous improvements in operational efficiency, inventory responsiveness, and technological integration between 2017 and 2023.

The strongest improvement was observed in intelligent systems utilization (+69.09%), followed by inventory turnover (+10.56%). Meanwhile, inventory holding periods, inventory costs, and inventory losses all declined, indicating a more efficient inventory management structure.

Taken together, these findings suggest that the expansion of AI-driven systems was associated with measurable improvements in inventory management performance and broader supply chain effectiveness.

Table 1. Amazon’s Inventory Management and AI Utilization Indicators (2017)

Variable	Value
Cost of Goods Sold (COGS)	USD 241.54 Billion
Average Inventory Value	USD 20.40 Billion
Inventory Holding Costs	USD 4.08 Billion
Damaged and Lost Inventory Value	USD 0.204 Billion
Intelligent Systems Utilization Rate	55%
Inventory Turnover Ratio	11.84 Times
Average Inventory Holding Period	30.82 Days
Inventory Holding Cost Ratio	20.0%

Damaged and Lost Inventory Ratio	1.0%
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Source: Calculated by the authors based on Amazon annual reports and operational disclosures (2017).

Table 2. Comparative Inventory Management Performance Indicators (2017–2023)

Indicator	2017	2023	Absolute Change	Percentage Change (%)
Inventory Turnover Ratio	11.84	13.09	+1.25	+10.56
Average Inventory Holding Period (Days)	30.82	27.89	-2.93	-9.51
Inventory Holding Cost Ratio (%)	20.00	18.00	-2.00	-10.00
Damaged and Lost Inventory Ratio (%)	1.00	0.90	-0.10	-10.00
Intelligent Systems Utilization (%)	55.00	93.00	+38.00	+69.09

Source: Authors' calculations based on Amazon financial statements and operational reports.

Figure 1. Inventory Turnover Ratio

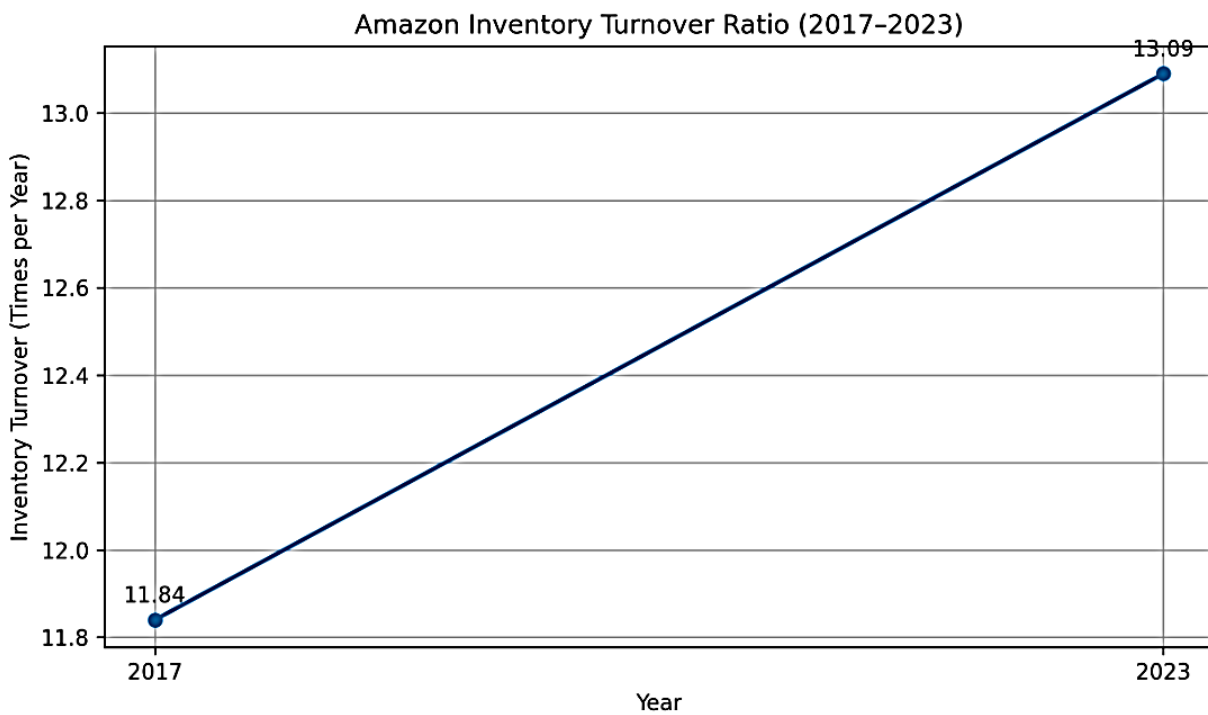


Figure 2. Average Inventory Holding Period (days)

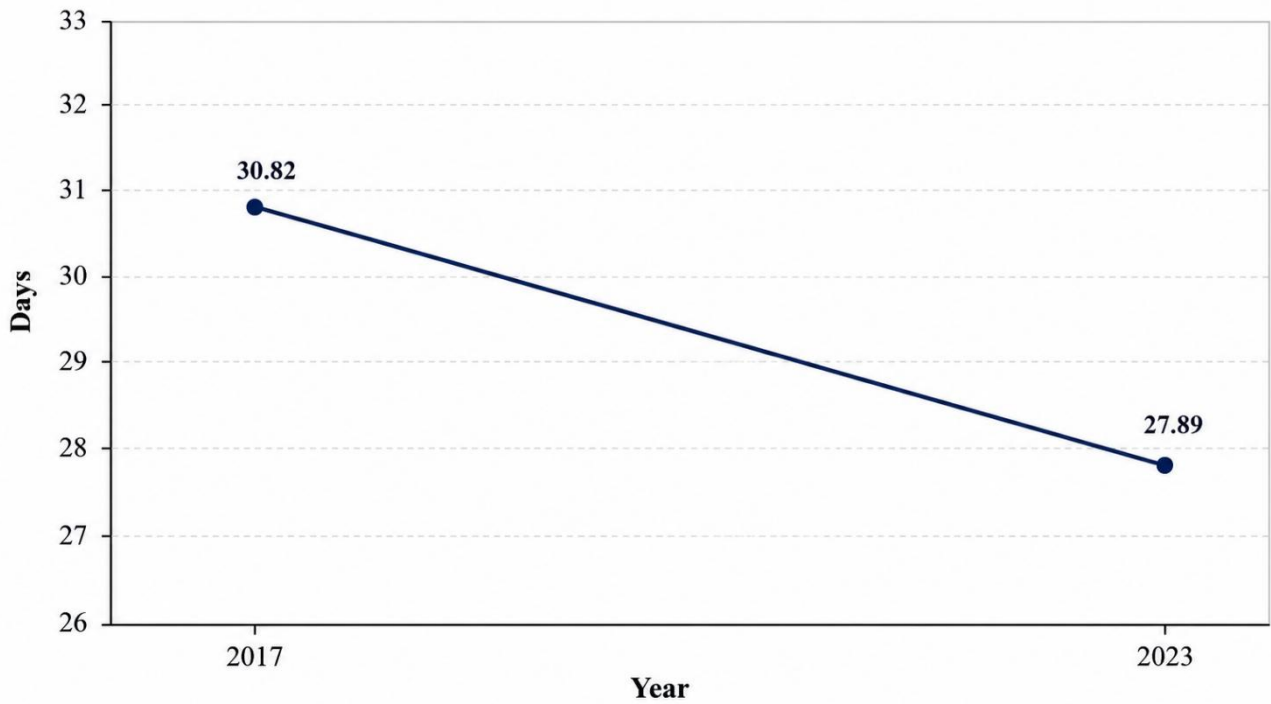
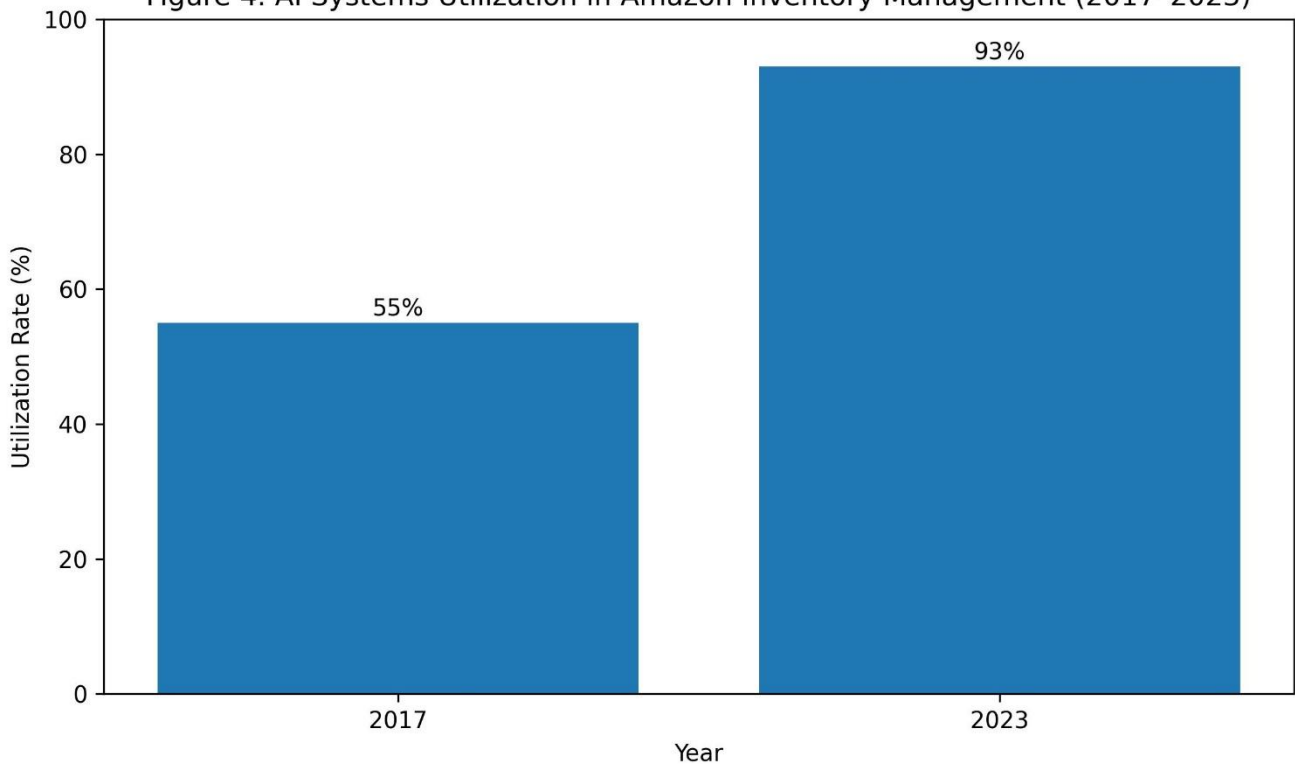


Figure 3. AI Usage in Inventory Management

Figure 4. AI Systems Utilization in Amazon Inventory Management (2017-2023)



5. Discussion

The findings of this study provide evidence that the growing integration of artificial intelligence technologies has been accompanied by measurable improvements in Amazon's inventory management performance. The increase in inventory turnover and the reduction in inventory holding periods suggest that AI-enabled forecasting and inventory optimization systems have enhanced the company's ability to align inventory levels with market demand. These findings are consistent with previous studies emphasizing the role of machine learning and predictive analytics in improving forecasting accuracy and reducing inventory inefficiencies (Wamba et al., 2020; Choi et al., 2018).

The decline in inventory holding costs further supports the argument that intelligent technologies contribute to more efficient resource allocation. By improving demand visibility and optimizing inventory placement decisions, AI systems enable organizations to reduce unnecessary stock accumulation while maintaining high service levels. This finding aligns with Christopher's (2022) argument that advanced inventory management systems can simultaneously enhance operational efficiency and cost effectiveness.

A notable outcome of the study is the reduction in damaged and lost inventory. Although the numerical decline appears relatively modest, the scale of Amazon's global operations means that even small percentage improvements may translate into substantial financial savings. The implementation of robotics, RFID-based tracking systems, and real-time monitoring technologies likely contributed to greater inventory accuracy and reduced operational losses.

The dramatic increase in intelligent systems utilization from 55% to 93% reflects Amazon's broader digital transformation strategy. Artificial intelligence has evolved from a supporting technological tool into a central component of operational decision-making. This transition illustrates how AI can influence not only inventory management but also overall supply chain responsiveness, resilience, and customer service performance.

Nevertheless, the findings should be interpreted with caution. While the observed improvements coincide with increased AI adoption, they cannot be attributed exclusively to artificial intelligence. During the same period, Amazon expanded its logistics infrastructure, invested heavily in warehouse automation, improved transportation networks, and increased operational scale. Consequently, the relationship identified in this study should be understood as an association rather than definitive causal proof.

Despite these limitations, the results demonstrate that artificial intelligence has become a critical enabler of inventory optimization in large-scale digital enterprises. The study contributes to the growing body of literature suggesting that AI-driven systems can improve inventory efficiency, reduce operational costs, strengthen supply chain performance, and support long-term competitive advantage in increasingly complex business environments.

6. Conclusion

This study examined the role of artificial intelligence in enhancing inventory management performance through an analytical case study of Amazon, one of the world's leading technology-driven supply chain organizations. The findings indicate that the growing adoption of AI-enabled technologies has been associated with measurable improvements in inventory management outcomes between 2017 and 2023.

The comparative analysis revealed improvements in inventory turnover, reductions in inventory holding periods, lower inventory-related costs, and decreased inventory losses. At the same time, the utilization of intelligent systems increased substantially, reflecting Amazon's transition toward a highly integrated digital operating environment. These developments suggest that artificial intelligence has contributed to greater operational responsiveness, more efficient resource utilization, and improved inventory visibility across the supply chain.

The study further demonstrates that AI technologies, including predictive analytics, machine learning algorithms, warehouse automation systems, and intelligent robotics, play an increasingly important role in supporting inventory optimization and logistics performance. By enabling more accurate demand forecasting and real-time operational decision-making, these technologies help organizations improve efficiency while maintaining high service levels.

Nevertheless, the findings also indicate that improvements in inventory performance cannot be attributed exclusively to artificial intelligence. Organizational expansion, infrastructure investments, process innovation, and broader digital transformation initiatives likely contributed to the observed outcomes. Therefore, AI should be viewed as a critical enabling capability operating within a wider ecosystem of technological and managerial innovations.

Overall, the study supports the growing consensus that artificial intelligence has evolved from a supplementary technological resource into a strategic organizational capability that enhances inventory management effectiveness, strengthens supply chain resilience, and contributes to sustainable competitive advantage in increasingly complex business environments.

7. Key Findings

The study generated several important findings regarding the relationship between artificial intelligence and inventory management performance:

1. The expansion of artificial intelligence adoption was associated with measurable improvements in inventory management efficiency.
2. Amazon's inventory turnover ratio increased between 2017 and 2023, indicating more effective inventory utilization and faster inventory circulation.
3. The average inventory holding period decreased, suggesting improved alignment between inventory levels and market demand.
4. Inventory holding costs declined, reflecting enhanced resource allocation and more efficient inventory planning processes.
5. The damaged and lost inventory ratio decreased, indicating improvements in inventory visibility, monitoring, and operational control.
6. The utilization of intelligent systems increased substantially, demonstrating the growing integration of artificial intelligence into core inventory management activities.
7. Predictive analytics and machine learning technologies contributed to more accurate demand forecasting and inventory replenishment decisions.
8. Warehouse automation and robotics supported operational efficiency by reducing processing times and minimizing operational errors.
9. The integration of AI with digital technologies such as IoT, cloud computing, and data analytics strengthened supply chain responsiveness and operational flexibility.
10. Artificial intelligence emerged as a strategic capability that supports both operational performance and long-term organizational competitiveness.

8. Recommendations

Based on the findings of this study, the following recommendations are proposed for organizations seeking to improve inventory management through artificial intelligence:

1. Increase investments in artificial intelligence technologies that support inventory forecasting, optimization, and real-time decision-making.
2. Expand the use of predictive analytics and machine learning models to improve demand forecasting accuracy and reduce inventory uncertainty.
3. Accelerate the adoption of warehouse automation technologies, including robotics and intelligent tracking systems, to improve operational efficiency.
4. Strengthen the integration of inventory management systems with IoT platforms, cloud-based infrastructure, and enterprise resource planning systems to enhance data visibility and coordination.
5. Prioritize data quality, governance, and data integration practices, as the effectiveness of AI systems depends heavily on the accuracy and reliability of available information.
6. Invest in workforce development programs that enhance employees' capabilities in managing and utilizing AI-driven technologies.
7. Develop organizational strategies that balance technological innovation with operational flexibility to maximize the benefits of digital transformation.
8. Encourage continuous monitoring and evaluation of AI implementation outcomes to ensure that technological investments generate measurable operational and financial benefits.

9. Promote sustainable inventory management practices by leveraging AI technologies to reduce waste, optimize resource consumption, and improve environmental performance.
10. Future research should employ broader datasets, multi-company comparisons, and advanced statistical techniques to further examine the causal relationship between artificial intelligence adoption and inventory management performance.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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All authors have read and approved the final version of the manuscript.

Data Availability Statement

The data supporting the findings of this study were obtained from publicly available sources, including Amazon's annual reports, corporate disclosures, and published industry reports. The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Ethical Approval

This study did not involve human participants, human data, human tissue, or experimental animals. Therefore, ethical approval was not required in accordance with institutional and international research ethics guidelines.

Informed Consent

Not applicable. This research did not involve human participants or personal data requiring informed consent.

Consent for Publication

Not applicable.

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Artificial Intelligence Disclosure Statement

The authors declare that artificial intelligence-assisted tools may have been used to support language editing, grammar refinement, and manuscript organization. All intellectual content, interpretation of findings, analysis, conclusions, and final editorial decisions remain the sole responsibility of the authors. The authors carefully reviewed and verified all content prior to submission.

Research Limitations

The study is based on a single-case analysis of Amazon and relies primarily on publicly available secondary data. Consequently, the findings should be interpreted with caution and may not be directly generalizable to all industries or organizational contexts. Future studies may benefit from multi-company comparisons and primary data collection approaches.

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