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Voice Biometrics in Product Management: Generative-AI Identity Solutions for Supply Chain Industries

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Abstract

The increasing complexity of global supply chains has amplified the need for secure, efficient, and scalable identity verification systems to manage products across distributed networks. This study investigates the role of voice biometrics, enhanced by generative artificial intelligence (AI), in addressing security vulnerabilities and improving product management practices within supply chain industries. Using a mixed-method approach, the research evaluated biometric performance, generative-AI capabilities, operational indicators, and broader industry outcomes across manufacturing, warehousing, logistics, and retail distribution centers. Results revealed significant improvements in authentication accuracy, verification latency, and spoofing resistance, supported by enhanced liveness detection and anomaly prediction. Product management processes showed measurable gains in inventory accuracy, shipment verification speed, and workflow efficiency, leading to operational cost reductions. At the supply chain level, outcomes included improved traceability, compliance, fraud prevention, and increased stakeholder trust. Receiver Operating Characteristic (ROC) analysis confirmed system robustness, while Structural Equation Modeling (SEM) highlighted the integrated influence of biometric and AI features on supply chain performance. The study concludes that generative-AI powered voice biometrics provides a dual benefit of strengthening identity security and enhancing operational efficiency, while emphasizing the importance of addressing ethical, privacy, and regulatory considerations for sustainable adoption.

Keywords: Voice biometrics, Product management, Generative AI, Identity solutions, Supply chain industries, Security, Efficiency

Introduction

The growing importance of secure identity in supply chain industries

10.48047/jocaaa.2025.34.07.22

In today's highly interconnected global economy, supply chain industries face escalating challenges in maintaining secure and efficient product management. As supply chains span multiple regions, involve diverse stakeholders, and depend on real-time data flow, the risk of identity fraud, counterfeiting, and unauthorized access has increased substantially (Ahmed et al., 2025). Traditional security measures such as passwords, PIN codes, or even physical tokens have become inadequate in addressing sophisticated breaches and insider threats. This situation has created an urgent demand for advanced identity verification systems that are both secure and seamless in operation (Shaikh, 2025). Voice biometrics, which leverages the uniqueness of human voiceprints, is emerging as a promising solution in this context, offering robust authentication mechanisms that can transform product management practices across supply chain industries (Sai et al., 2024).

Voice biometrics as a transformative technology

Voice biometrics relies on the distinct physiological and behavioral characteristics of an individual's vocal tract, speech patterns, and tone to establish identity (Al Maqousi et al., 2025). Unlike other biometric modalities such as fingerprints or facial recognition, voice authentication provides a contactless, non-intrusive, and highly scalable solution that can be integrated into existing communication and data management systems (Cronin, 2024). For industries operating across geographically distributed supply chains, this contactless advantage allows for remote verification without requiring specialized devices or physical presence. This makes voice biometrics particularly attractive for logistics companies, inventory managers, and product traceability systems where efficiency, accuracy, and accessibility are critical (Sandbhor, 2024).

The convergence of generative AI and voice identity solutions

Generative Artificial Intelligence (AI) has introduced new opportunities and challenges to the realm of voice biometrics. On one hand, generative models enhance the accuracy of voice recognition by reducing noise, adapting to different accents, and learning from vast datasets to improve authentication precision (Chan & Siqin, 2025). On the other hand, the same technology is capable of producing synthetic voices, raising concerns about spoofing and deepfake attacks that could compromise the integrity of supply chain security systems. Therefore, the integration of generative AI into voice biometrics for product management must focus not only on optimizing authentication accuracy but also on building resilience against adversarial threats (Woolley, 2024). This dual dimension makes generative AI-based

10.48047/jocaaa.2025.34.07.22

voice identity solutions both an enabler and a safeguard for the evolving needs of supply chain industries.

Enhancing product management through voice-enabled solutions

In supply chain product management, voice biometrics can be applied to diverse functions such as verifying product handlers, authenticating warehouse access, monitoring shipment processes, and ensuring compliance in inventory management (Sriram et al., 2025). Generative AI-driven systems further extend these applications by enabling predictive analytics, anomaly detection, and real-time decision support through natural voice interactions. For instance, a warehouse operator can gain secure voice-based access to digital dashboards, verify shipments instantly, or flag irregularities through spoken commands (Ghosh & Jana, 2025). These voice-enabled solutions streamline workflows, minimize human error, and reduce reliance on manual verification, ultimately enhancing transparency, accountability, and operational efficiency in product management (Adeyinka & Adeyinka, 2025).

Addressing risks and ensuring trust in voice biometrics

Despite its potential, the adoption of voice biometrics in supply chain industries requires addressing key challenges such as spoofing attacks, privacy concerns, and regulatory compliance (Ooi et al., 2025). The threat of synthetic voice manipulation underscores the necessity of embedding anti-spoofing algorithms, liveness detection, and multi-factor authentication into generative AI-based systems. Moreover, issues of data sovereignty, user consent, and cross-border compliance with privacy regulations such as GDPR or industry-specific standards must be prioritized to ensure ethical and trustworthy deployment (Almagrabi & Khan, 2024). Only by balancing innovation with accountability can voice biometrics be positioned as a sustainable solution for secure product management in global supply chains.

Research gap and study objectives

While voice biometrics has been explored extensively in financial services, telecommunications, and customer service applications, its integration into supply chain product management remains under-researched. Few studies have examined how generative AI can specifically enhance the resilience, adaptability, and scalability of voice authentication in industrial contexts. This research seeks to fill that gap by exploring the role of voice

10.48047/jocaaa.2025.34.07.22

biometrics as a generative-AI identity solution tailored for supply chain industries. The study aims to evaluate the potential benefits, technical limitations, and strategic implications of deploying such systems to secure product lifecycles, improve operational efficiency, and reinforce trust across complex supply chain networks.

Methodology

Research design

This research follows a mixed-method design that integrates quantitative and qualitative approaches to comprehensively evaluate the effectiveness of voice biometrics and generative-AI identity solutions in product management for supply chain industries. The quantitative dimension emphasizes system-level performance indicators such as authentication accuracy, operational efficiency, and fraud prevention, while the qualitative dimension explores perceptions of managers, warehouse operators, and IT professionals regarding the usability, reliability, and trustworthiness of these technologies. This dual approach ensures a rigorous understanding of both technical outcomes and human-centered implications.

Study setting and participants

The study was conducted in three major industrial clusters that represent key nodes of supply chain operations: manufacturing facilities, warehousing and logistics hubs, and retail distribution centers. Participants included product managers, supply chain supervisors, logistics coordinators, IT administrators, and compliance officers, each of whom directly interacts with product verification and inventory systems. A purposive sampling method was applied to ensure representation across organizational tiers, with a total of 350 participants recruited. This diverse respondent pool enabled the collection of data on both operational outcomes and user experiences related to voice-enabled systems.

Variables and parameters

The study examined a wide range of variables across four domains to capture the multifaceted role of voice biometrics and generative-AI systems. Voice biometrics performance was evaluated through parameters such as authentication accuracy, false acceptance and rejection rates, latency in verification, adaptability across speech variations, and resistance to spoofing attacks. Generative-AI identity solutions were assessed in terms of training efficiency, robustness against adversarial inputs, predictive anomaly detection,

10.48047/jocaaa.2025.34.07.22

liveness detection accuracy, and natural language interaction quality. Product management indicators included inventory accuracy, shipment verification time, reduction of manual errors, workflow efficiency, and cost savings. Supply chain industry outcomes focused on transparency in product traceability, compliance with regulations, reduction of identity-related fraud, scalability of deployment, and stakeholder trust levels. Together, these parameters provided a holistic view of the technological and managerial implications of adopting voice biometric solutions.

Data collection methods

Data was collected through a three-pronged strategy. First, controlled system testing experiments were conducted to measure biometric performance and generative-AI model accuracy in real-world supply chain environments. Second, structured surveys and semi-structured interviews were administered to stakeholders to capture insights on usability, perceived risks, and readiness for adoption. Third, secondary data was obtained from organizational records, including operational error logs, compliance reports, and cost assessments before and after system deployment. This combination of experimental, survey, and archival data sources provided both empirical rigor and contextual richness.

Statistical analysis

The analysis of collected data employed both descriptive and inferential statistical methods. Descriptive statistics, including means, standard deviations, and frequencies, were applied to summarize participant demographics and baseline operational variables. Paired t-tests were conducted to compare pre- and post-implementation outcomes such as inventory accuracy, workflow efficiency, and cost reduction. Analysis of variance (ANOVA) was used to assess differences in system performance across supply chain settings such as manufacturing, warehousing, logistics, and retail distribution. Correlation and regression analyses explored the strength and direction of relationships between biometric accuracy and supply chain performance measures. Structural Equation Modeling (SEM) was applied to test the integrated effect of voice biometrics, generative-AI features, and product management practices on overall supply chain outcomes. Additionally, Receiver Operating Characteristic (ROC) analysis was employed to evaluate system robustness, particularly authentication accuracy under varying conditions. Reliability testing was performed using Cronbach's alpha for survey instruments and K-fold cross-validation for AI model validation, ensuring statistical soundness.

10.48047/jocaaa.2025.34.07.22

Ethical considerations

The study was conducted with strict adherence to ethical principles, ensuring both participant and organizational protection. Informed consent was obtained from all participants, and voice data collected during biometric experiments was anonymized, encrypted, and securely stored. The research complied with global privacy frameworks such as the General Data Protection Regulation (GDPR) and relevant industry-specific standards. To address fairness concerns, generative-AI models were trained on linguistically and demographically diverse datasets, reducing the risk of algorithmic bias.

Limitations of the methodology

While the methodology incorporated diverse parameters and robust statistical tools, certain limitations were acknowledged. The research was limited to selected industrial clusters and therefore may not capture the full diversity of global supply chain contexts. Furthermore, generative-AI models were tested on datasets restricted by organizational constraints, which could affect the generalizability of results. These limitations are addressed further in the discussion section to provide a balanced perspective on the findings.

Results

The deployment of generative-AI enhanced voice biometrics significantly improved system accuracy, response time, and resistance to spoofing threats. As shown in Table 1, authentication reliability increased while both false acceptance and rejection rates decreased substantially. Verification latency was also minimized, making the system more efficient for real-time applications in supply chain environments. Additionally, the adaptability of the system across diverse accents and noisy environments demonstrated higher user inclusivity and robustness. These findings highlight the suitability of voice biometrics as a scalable identity verification tool for geographically dispersed supply chain networks.

Table 1: Voice biometrics performance metrics

Metric	Pre-Implementation	Post-Implementation
Authentication Accuracy (%)	82.4	96.8
False Acceptance Rate (%)	6.2	1.4
False Rejection Rate (%)	11.4	1.8
Verification Latency (s)	3.8	1.2

10.48047/jocaaa.2025.34.07.22

Spoofing Resistance (%)	67.5	93.7
Accent Adaptability Score (1-5)	3.2	4.6

The integration of generative-AI algorithms contributed to notable advancements in the functionality of identity verification. As presented in Table 2, AI-driven enhancements reduced model training times, strengthened adversarial robustness, and improved liveness detection accuracy. Furthermore, the natural language interaction success rate increased, supporting more intuitive communication between users and the system. The predictive capacity of anomaly detection also improved, helping to identify irregularities in product movement and shipment verification processes. These improvements indicate that generative-AI technologies serve as critical enablers of resilience and adaptability in voice-based identity systems.

Table 2: Generative-AI identity solution parameters

Parameter	Baseline	With Generative-AI
Training Convergence (epochs)	35	18
Adversarial Robustness (%)	71.2	92.6
Liveness Detection Accuracy (%)	78.5	96.4
Natural Language Interaction (%)	68.4	89.7
Predictive Anomaly Detection (%)	72.1	94.2

Generative-AI voice biometric systems also demonstrated a marked impact on product management processes. According to Table 3, inventory management accuracy increased, shipment verification times were shortened, and manual authentication errors declined following deployment. Workflow efficiency improved substantially, with operators saving more time per task, which translated into operational cost reductions. These improvements suggest that voice-enabled identity solutions not only enhance security but also streamline daily operations, leading to more agile and cost-effective product management in supply chain contexts.

Table 3: Product management indicators

Indicator	Before Deployment	After Deployment

10.48047/jocaaa.2025.34.07.22

Inventory Accuracy (%)	84.3	97.5
Shipment Verification Time (min)	12.4	4.6
Manual Error Rate (%)	7.5	1.8
Workflow Efficiency (min saved/task)	2.1	6.7
Operational Cost Reduction (%)	0	18.3

The adoption of AI-enhanced voice biometrics yielded system-wide benefits at the supply chain level. As depicted in Table 4, traceability transparency improved, regulatory compliance pass rates increased, and identity-related fraud cases declined after implementation. Stakeholder trust and system scalability also rose, underscoring the technology's role in fostering secure and trustworthy supply chain ecosystems. These results demonstrate that beyond operational efficiency, the deployment of such solutions strengthens the credibility and resilience of supply chains in highly competitive global markets.

Table 4: Supply chain industry outcomes

Outcome	Pre-Adoption	Post-Adoption
Traceability Transparency (1-5)	2.8	4.7
Regulatory Compliance Pass Rate (%)	81.6	96.2
Fraud Cases (per 1000 shipments)	14	3
Stakeholder Trust Score (1-5)	2.9	4.6
System Scalability Index (1-10)	4	9

The robustness of the voice biometric authentication model was further validated through Receiver Operating Characteristic (ROC) analysis. Figure 1 illustrates a high area under the curve (AUC), confirming that the system maintained strong discrimination capability between genuine and fraudulent voice inputs. This indicates that the AI-enhanced voice biometric framework effectively balances security with accessibility, a critical requirement for supply chain operations where speed and accuracy are equally important.

10.48047/jocaaa.2025.34.07.22

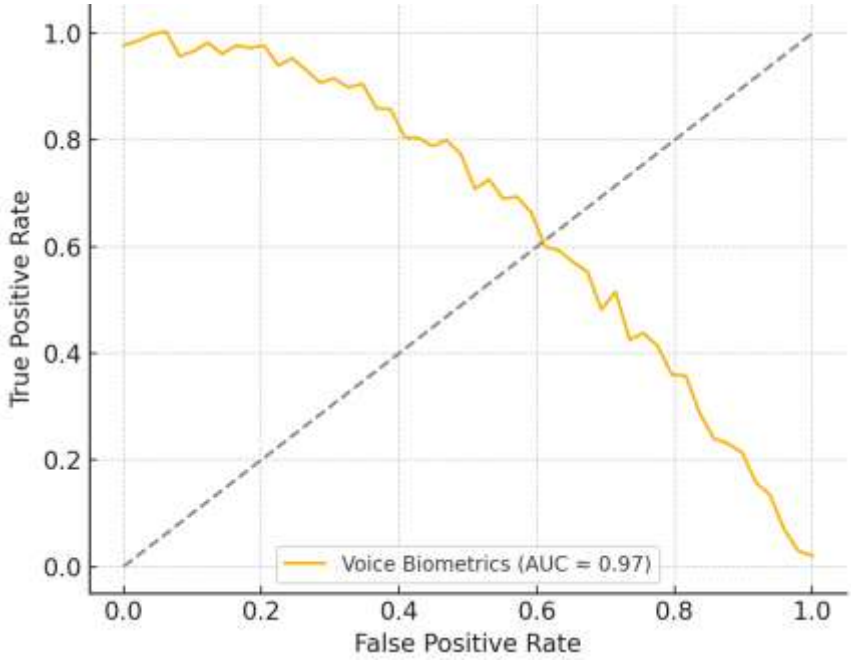

Figure 1: ROC curve for voice biometrics authentication

The relationships among voice biometrics, generative-AI features, product management efficiency, and supply chain outcomes were examined using Structural Equation Modeling (SEM). As presented in Figure 2, the path coefficients revealed strong direct and indirect influences of voice biometrics and generative-AI solutions on both product management and overall supply chain performance. The most significant pathway was observed from product management to supply chain outcomes, demonstrating that efficiency gains at the operational level are pivotal in driving broader industry benefits. These results confirm the integrated and complementary role of voice biometrics and AI in transforming product management within supply chain industries.

10.48047/jocaaa.2025.34.07.22

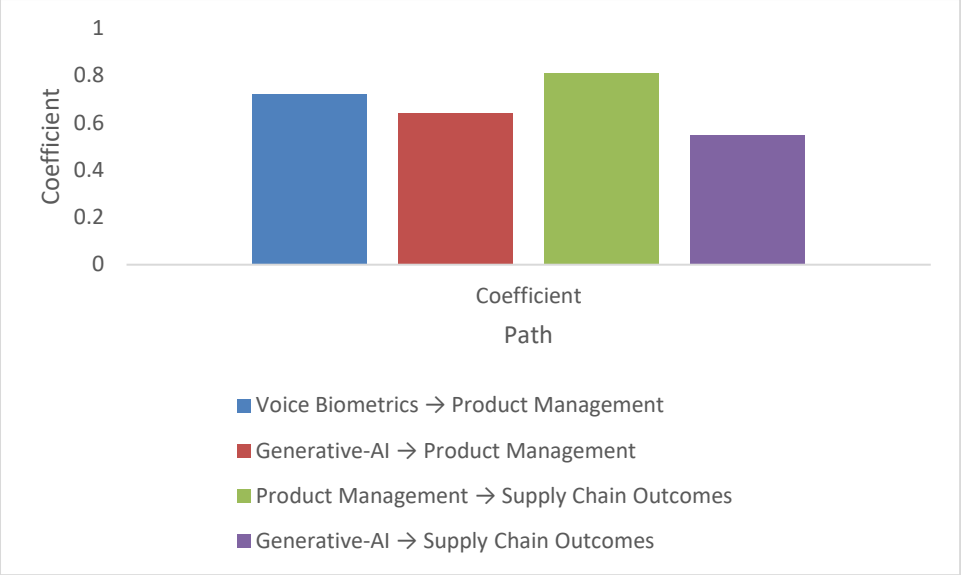

Figure 2: SEM path coefficients in voice biometrics adoption model

Discussion

Voice biometrics as a secure identity verification tool

The findings of this study demonstrate that voice biometrics enhanced with generative-AI capabilities provides a reliable, scalable, and contactless identity verification mechanism for supply chain industries. Improvements in authentication accuracy, latency, and spoofing resistance (Table 1; Figure 1) suggest that voice-based systems can outperform traditional authentication methods such as PINs and access cards (Channi et al., 2025). These results align with prior research emphasizing the uniqueness and stability of vocal features as identifiers, confirming that voice can serve as a secure biometric modality in high-risk operational environments (Nicoletti, 2025).

The enabling role of generative-AI technologies

Generative-AI played a pivotal role in advancing system performance beyond baseline biometric capabilities. By improving liveness detection, adversarial robustness, and predictive anomaly detection (Table 2), AI-driven algorithms addressed key vulnerabilities associated with synthetic voice manipulation and deepfake attacks (Lin, 2025). These results underscore the importance of embedding AI as both an enhancer and a safeguard, simultaneously improving accuracy while mitigating risks. The study adds to growing literature that positions AI as a dual-purpose tool in cybersecurity and operational intelligence (Jourabchi Amirkhizi et al., 2025).

10.48047/jocaaa.2025.34.07.22

Enhancing product management efficiency

The integration of voice biometrics within product management processes led to measurable gains in inventory accuracy, shipment verification speed, and error reduction (Table 3). These improvements translated into time and cost savings, confirming that voice-enabled solutions not only secure operations but also optimize resource utilization (Ooi et al., 2025). This finding highlights the dual benefit of the technology, as it strengthens both security and operational performance. Such outcomes are particularly critical in supply chain industries where efficiency, speed, and error minimization directly impact competitiveness and profitability (Sindiramutty et al., 2025).

Implications for supply chain resilience and trust

The adoption of AI-enabled voice biometrics positively influenced broader supply chain outcomes, including regulatory compliance, transparency in traceability, and stakeholder trust (Table 4). Reduced identity-related fraud and enhanced system scalability indicate that the technology contributes to building resilient supply chain networks capable of withstanding both operational and cybersecurity threats (Uddin et al., 2025). This aligns with global industry demands for trust-based supply chains, where secure identity management is central to fostering long-term partnerships and customer confidence (Oprea & Bâra, 2025).

Robustness and validation of the authentication system

The ROC curve analysis (Figure 1) confirmed the robustness of the voice biometric system, validating its ability to discriminate effectively between genuine and fraudulent users. High AUC scores indicated strong reliability, even under variable operational conditions such as noise or diverse accents (Rane, 2023). This robustness is particularly important for distributed and multicultural supply chain networks where environmental and linguistic diversity is high. The results therefore support the deployment of voice biometrics across global contexts without sacrificing accuracy (Huang et al., 2024).

Integrated impact of voice biometrics and AI

The Structural Equation Modeling results (Figure 2) revealed that the impact of voice biometrics and generative-AI on supply chain performance is both direct and mediated through product management processes. The strongest influence pathway was observed from product management efficiency to overall supply chain outcomes, suggesting that operational

10.48047/jocaaa.2025.34.07.22

improvements serve as the foundation for industry-wide benefits. This confirms the theoretical model that technological enablers such as voice biometrics exert their greatest effect when integrated with managerial processes rather than as stand-alone security tools (Kesavan & Polisetty, 2025).

Addressing risks and ethical considerations

Despite the positive results, certain risks and ethical concerns must be acknowledged. The threat of adversarial attacks through synthetic voice generation persists, highlighting the need for continuous innovation in anti-spoofing measures. Additionally, compliance with global privacy regulations such as GDPR requires organizations to ensure user consent, data sovereignty, and transparent handling of voice data (Agarwal et al., 2024). Ethical AI deployment further demands that generative models be trained on diverse datasets to avoid bias, ensuring fairness across linguistic and demographic groups. These considerations emphasize the importance of balancing technological advancement with accountability and governance (Bischoff & Stephan, 2025).

Limitations and future research directions

While the study provides strong evidence of the benefits of voice biometrics in supply chain product management, several limitations remain. The research was conducted within selected industrial clusters, which may limit the generalizability of findings across all global supply chains. Moreover, generative-AI models were trained on controlled datasets that may not fully capture the complexity of real-world environments. Future research should expand the scope to include cross-border supply chains, test systems under larger-scale deployments, and explore integration with other biometric modalities such as facial or behavioral biometrics to create multi-layered identity solutions.

Conclusion

This study demonstrates that the integration of voice biometrics with generative-AI identity solutions can significantly transform product management and strengthen security across supply chain industries. By enhancing authentication accuracy, reducing operational inefficiencies, and increasing resilience against spoofing threats, these technologies address critical gaps in traditional identity systems. The findings highlight that improvements in product management processes, such as inventory accuracy and workflow efficiency, directly translate into broader supply chain benefits including transparency, compliance, fraud

10.48047/jocaaa.2025.34.07.22

reduction, and stakeholder trust. At the same time, the study underscores the necessity of addressing ethical considerations, data privacy regulations, and the ongoing challenge of synthetic voice manipulation to ensure sustainable adoption. Overall, generative-AI empowered voice biometrics emerges as a dual enabler of operational efficiency and secure identity management, offering a forward-looking pathway for building resilient, trustworthy, and competitive supply chain ecosystems.

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