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Integrating the Internet of Everything and Artificial Intelligence in Reverse Logistics to Prepare for Industrial Revolution 5.0

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Abstract

This study explores the integration of Artificial Intelligence (AI) and Internet of Everything/Internet of Things (IoE/IoT) technologies in the realm of reverse logistics. The research investigates the extent to which these advanced technologies are incorporated and their impact on logistics operations through an in-depth analysis of seven prominent companies across various industries. The study reveals that a high degree of AI and IoE/IoT integration is prevalent among the examined companies that enhance supply chain visibility, real-time tracking, and operational efficiency. The study objects to offer valuable implications for businesses striving to enhance their supply chain practices. It illuminates the nuanced amalgamation of AI and IoE/IoT in the realm of reverse logistics to enrich the collective cognizance and provide a compass for enterprises endeavoring to amplify the prowess of their supply chain management.

Keywords: Reverse logistics, Artificial Intelligence, Internet of Things, Internet of Everything, Supply Chain Management, Industrial Revolution, Operational Efficiency.

Introduction

Business experts believe that Industrial Revolution 4.0 is on the verge of its end and Industrial Revolution 5.0 is peeking to look for a way to make a grand entry. As current business practice has to adapt with every change, welcoming Industrial Revolution 5.0 is a significant concern. To remain at the edge in the global competition businesses have to prepare every part for IR 5.0. The most talked about and important part of IR 5.0 that is shifting IR 4.0 towards IR 5.0 is the Internet of Everything (IoE) and Artificial Intelligence (AI). The use of IoE and AI in business operational aspects and decision-making is evident. Also, businesses use it for streamlining processes, enhancing customer service, automating repetitive tasks in finance and accounting, and improving energy management in facilities, sustainability efforts, and many parts of the supply chain. But what about reverse logistics which is a must to focus on part of today's business? In the context of a new era of transformation across various industries, the logistics sector stands at the forefront of this journey with its intricate and essential role in supply chains. Especially, Reverse logistics, the process of managing product returns, refurbishment, recycling, and disposition, has gained increasing attention as a critical aspect of customer experience, sustainability, and resource optimization should be prepared for the dawn of Industrial Revolution 5.0. This is why the research delves into the multifaceted relationship between IoE, AI, and reverse logistics. It aims for understanding the integration of IoE and AI in reverse logistics for unlocking unprecedented opportunities to revolutionize processes of Supply Chain Management (SCM) and adapt to the changing business landscape.

Scope and Objectives

The convergence of IoE and AI technologies holds immense potential to enhance efficiency, visibility, and decision-making in reverse logistics operations. The paper seeks to examine the relationship of IoE, AI, and reverse logistics to draw the implications requires to make reverse logistics ready for IR 5.0. The study seeks to identify the key applications, benefits, and challenges of adopting IoE and AI in reverse logistics processes by synthesizing existing literature and industry data. Besides, the paper aims to develop a framework to elucidate the intricate connections

between these technologies and the transformation of reverse logistics in the face of Industrial Revolution 5.0 for better supply chain management.

Literature Review

IoE and AI for Business

The convergence of the Internet of Everything (IoE) and Artificial Intelligence (AI) heralds the next frontier in the digital age, poised to reshape industries and pave the way for Industrial Revolution 5.0 (IR 5.0). IoE is expanding beyond the Internet of Things (IoT), integrating humans, processes, and data into a cohesive network, enabling seamless communication and data exchange, and unlocking a wealth of real-time insights for businesses (Miraz et al., 2015). Paired with AI's cognitive capabilities, this combination forms a formidable force that empowers machines to learn, adapt, and make data-driven decisions like never before.

According to (Nayak and Patgiri, 2022), as organizations embrace this synergy, the integration of IoE and AI into business operations has become a game-changer. In manufacturing, smart sensors and IoE devices facilitate the collection of real-time data (Barnaghi et al., 2013), while AI algorithms enable predictive maintenance and quality control, optimizing production and product quality (Lee et al., 2019). Similarly, in the retail sector, the amalgamation of IoE and AI personalizes customer experiences by analyzing historical data, preferences, and behavior patterns. This results in targeted marketing campaigns that enhance customer retention and satisfaction.

IoE and AI play a significant role in data-driven decision-making in businesses. The continuous data streams from IoE devices, coupled with AI-powered analytics, provide real-time insights into operations, customer behavior, and market trends (Hamilton, 2019). Armed with this intelligence, businesses can respond swiftly to changes, make informed decisions, and gain a competitive edge.

However, the integration of IoE and AI is not without challenges and ethical considerations. As per Atlam and Wills (2020), the vast volume of interconnected data demands robust data management and privacy protection measures to safeguard sensitive information. Ensuring data security and compliance with regulations is of utmost importance. Amugongo et al., 2023 add that

the ethical use of AI raises concerns about transparency, bias, and fairness. Businesses must deal with these challenges responsibly to build trust and ensure the ethical deployment of these transformative technologies.

As businesses increasingly harness the potential of IoE and AI, they are well-positioned to embrace the vision of Industrial Revolution 5.0. This new era is characterized by intelligent, interconnected systems that drive innovation, efficiency, and sustainability (Cui et al., 2023). Leveraging the power of IoE and AI, businesses can forge a path toward a future where data-driven decision-making and digital transformation are at the heart of every operation and establish prosperity in the ever-evolving landscape of the digital economy.

IoE and AI in Supply Chain Management

the Internet of Everything (IoE) as an evolved IoT represents a potential future scenario where various objects, including people, processes, and data, are interconnected and involved in operations. (Snyder and Bard, 2017). According to (Dolgui and Ivanov, 2022), the integration of the Internet of Everything (IoE) in supply chain management has emerged as a transformative force that reshapes traditional business operations. As per DeNardis's (2020) view IoE expands the scope of the Internet of Things (IoT) by connecting not only physical objects but also humans, processes, and data. It establishes a comprehensive ecosystem of interconnected elements. This interconnectedness facilitates real-time data exchange, advanced analytics, and intelligent decision-making across the supply chain (Di Martino et al., 2018)

Similarly, Artificial Intelligence (AI) has revolutionized supply chain management by enabling advanced data analysis, automation, and predictive capabilities (Dash et al., 2019). AI algorithms process vast volumes of data that help in identifying patterns and insights usually overlooked by human operators (Arinez et al., 2020). This technology empowers supply chain professionals to make data-driven decisions and respond proactively to changing market dynamics (Patil et al., 2023).

Reverse Logistics

Reverse logistics is a pivotal component of supply chain management which refers to the process of managing the return, repair, recycling, or disposal of products after their initial sale (Agrawal et al., 2015). Reverse logistics encompasses the intricate processes of managing the flow of products from their final destination back to the manufacturer or appropriate disposal channels. According to Wang et al. (2017), the importance of effective reverse logistics has grown significantly with the rise of e-commerce and increasing environmental concerns. However, Misli and Less (2017) say that the field has challenges like optimizing return routes, refurbishing or repackaging returned goods, and minimizing waste. Ahlström et al. (2020) argue that companies are increasingly recognizing the potential for improved sustainability, reduced costs, and enhanced customer satisfaction that can be enabled through efficient reverse logistics strategies. The integration of technologies like the Internet of Everything (IoE) and Artificial Intelligence (AI) brings opportunity to revolutionize this aspect of supply chain management (Munirathinam, 2020). These technologies can streamline processes, enhance visibility, and provide data-driven insights for better decision-making. Investigating the integration of IoE and AI in reverse logistics is crucial to unlocking its potential benefits and shaping the future of this essential business function as businesses strive to cope with their operations with the demands of the Fourth Industrial Revolution (Munirathinam, 2020).

IoE, AI, and Reverse Logistics

The integration of the Internet of Everything (IoE) and Artificial Intelligence (AI) has the potential to revolutionize reverse logistics. IoT facilitates real-time visibility and connectivity of products throughout their lifecycle in reverse logistics from the point of return to final disposition (Hrouga, 2022). Smart sensors and connected devices enable seamless tracking, monitoring, and data exchange. In exchange, it enables businesses to gain deeper insights into the reverse logistics process (Koot et al., 2021). With the use of the power of IoE in reverse logistics aspects companies can optimize product returns, refurbishment, and recycling. This reduces the processing times and enhances customer experience. Real-time data collected through IoE devices empowers businesses to detect defects, identify potential quality issues, and implement corrective actions promptly (Mohammadian, 2019). As a result, it allows reducing waste and lowering operational costs.

AI in Reverse Logistics helps with its capability to process vast amounts of data and learn from patterns and complements IoE in reverse logistics by providing intelligent decision-making and automation (Jović et al., 2020). According to Campbell et al. (2020), AI algorithms can analyze historical return data, customer behavior, and market trends to predict demand patterns and optimize inventory management for returned products. Also say that AI-driven predictive analytics can help identify the most efficient reverse logistics routes (Wilson et al., 2022). It results allowing transportation costs and carbon footprint reduction. The AI-powered chatbots and virtual assistant integration in customer service facilitate quick and personalized responses to return inquiries to ensure customer satisfaction (Hoyer et al., 2020). However, Data security and privacy concerns are prominent in such integration.

Methodology

The methodology employed in this study involves a thorough analysis of the integration of Artificial Intelligence (AI) and the Internet of Everything/Internet of Things (IoE/IoT) in logistics and focuses on its implications for reverse logistics within the context of the Industrial Revolution 5.0. For the success of the methodology, secondary data will be gathered from reputable sources including articles, journals, company websites, and official reports. Secondary data collection enriches the study by drawing on existing information from reputable sources and offers a comprehensive foundation for analysis and insights. Based on the data qualitative and quantitative analysis will be performed. The qualitative analysis delves into the qualitative data obtained, unraveling underlying themes, patterns, and nuances to provide a deeper understanding of the subject matter (Talanquer, 2014). The qualitative analysis will involve extracting pertinent information about AI and IoE/IoT applications from the collected data, with a focus on identifying common use cases within logistics for each company. The quantitative analysis employs numerical data and statistical tools to quantify trends, relationships, and outcomes, offering empirical evidence to support and enhance the study's findings and conclusions (Mohajan, 2020). Quantitative analysis will be conducted to ascertain the number and percentage of companies using AI and IoE/IoT in logistics. Besides, AI and IoE/IoT Integration Indexes will be developed to gauge the extent of integration for each company. A specific IoE Integration Index will be devised

where applicable. Also, the level of integration as high, medium, or low will be categorized with the intention to reveal insights into the readiness of companies for AI and IoE/IoT integration in reverse logistics. Ultimately, this methodological approach will offer a holistic understanding of the potential of integrating AI and IoE/IoT in reverse logistics and its calibration with the forthcoming Industrial Revolution 5.0 as well as acknowledge the potential limitations and future research opportunities.

Analysis

IoE usage is still in practice and full integration of AI and IoE is still a potential. This is why the analysis will cover the integration of AI and IoE/IoT in logistics in different companies to understand the potential rate of integration of AI and IoE in reverse logistics as well as the benefits. Also, it will provide insight onto if they can make reverse logistics ready for Industrial Revolution 5.0.

Qualitative Analysis

Upon secondary data collection via articles, journals, company website, and company report following data was obtained.

Companies	Use of AI	Use of IoT/IoE
Amazon	Amazon employs AI to enhance supply operations and analyze data, automating tasks like predicting customer demand, managing product availability, optimizing delivery routes, and personalizing customer communication. This AI-driven approach ensures efficient one-day delivery (Eitel-Porter, 2021; Chan et al., 2022).	Amazon uses IoT through AWS Lambda to process incoming telemetry, update vehicle status, and manage data for Amazon Locations. The IoT-powered system aids warehouse management, with computers guiding optimal routes and IoT devices assisting logistics managers in locating products like ice cream for prompt delivery (Engdahl, 2022).

Nestle	Nestle utilizes AI, harnessing SAS analytics for minimizing inventory issues and enhancing supply chains. Predictive analytics and robotics aid in factory automation and supply chain traceability (Nestlé, 2023).	IoT is integrated to enhance sustainability, logistics, and production, employing sensors for tracking materials and optimizing critical processes, and installing state-of-the-art digital technology such as IoE that will accelerate improvement in sustainability, logistics, and production capacity. (Creasey, 2022).
Arla	Arla employs AI-based ORTEC Routing and Dispatch for operational planning, integrating it with SAP and mobile solutions for accurate real-time planning (ORTEC, 2023)	For IoT, Arla partners with AddSecure Verilocation, benefiting from customizable IoT-enabled fleet management that improves precision and eliminates human errors in logistics (AddSecure, 2022).
Mondelez International	Mondelez International implements AI/ML and cloud-based IoT solutions for optimizing warehouse and transport management. These technologies enhance route planning and vehicle load utilization, while digital track and trace ensure real-time product monitoring (Rana, 2022).	
Dundee Precious Metals	Dundee Precious Metals uses AI in mining operations but not logistics (Person, 2020).	IoE has enabled real-time sharing of critical information, including miner and equipment updates, enhancing safety and monitoring vehicle status (Iscoop, 2021).
UPS	UPS employs AI through its "ORION" system for route	UPS utilizes IoE for real-time updates on shipments and trucks,

	optimization, intelligently selecting efficient routes for drivers based on package details (Holland et al., 2017).	enhancing delivery efficiency (Kanade, 2022).
Johnson & Johnson	Johnson & Johnson's Advance Case Management platform employs AI algorithms to digitize processes, reducing logistics touchpoints (Shapiro, 2023).	Johnson & Johnson leverages IoT for tracking and tracing products across the supply chain (Kanade, 2022). It is transitioning towards IoE to develop self-driving systems that generate accurate production forecasts. This aids in optimizing logistics networks and significantly reducing cycle time (Ackerman and Krigsman, 2019).

Table-1: AI and IoT/IoE integration in logistics (Self-made).

Quantitative Analysis

The Most Common Use of AI and IoE/IoT in Logistics can be found:

- The most common use of AI in logistics is "Optimizing delivery routes" and "Predictive analytics for demand planning and supply chain traceability.
- The most common use of IoE/IoT in logistics is "Real-time tracking and monitoring of shipments" and "Fleet management with IoT connectivity for full visibility."

However, to see the integration level and possibilities of integrating them in reverse logistics some calculation needs to be performed. The following covers the quantitative analysis for gathering required insights:

Percentage Calculation for AI and IoT/IoE

Aspect	Total Companies	Number of Companies using AI or IoE/IoT	Percentage
Using AI in Logistics	7	6 (Amazon, Nestle, Arla, Mondelez International, UPS, Johnson & Johnson)	85.71%
Using IoE/IoT in Logistics	7	7 (Amazon, Nestle, Arla, Mondelez International, Dundee Precious Metals, UPS, Johnson & Johnson)	100%

Table-2: Percentage Calculation for AI and IoT/IoE (Self-made).

Integration Index

AI Integration Index

The following shows the AI Integration Index for each company based on the extent of AI usage in logistics. The index will be calculated as follows:

AI Integration Index = (Number of AI Use Cases / Total Possible AI Use Cases) x 100

Based on the information gathered:

Companies	AI Integration Index	Result
Amazon	(2 / 2) x 100	100
Nestle	(2 / 2) x 100	100
Arla	(1 / 1) x 100	100

Mondelez International	(1 / 1) x 100	100
Dundee Precious Metals	(0 / 1) x 100	0
UPS	(1 / 1) x 100	100
Johnson & Johnson	(1 / 1) x 100	100

Table-3: AI Integration Index (Self-made).

IoE/IoT Integration Index

The following shows the IoE/IoT Integration Index for each company based on the extent of IoE/IoT usage in logistics. The index will be calculated as follows:

IoE/IoT Integration Index = (Number of IoE/IoT Use Cases / Total Possible IoE/IoT Use Cases) x 100

Based on the information gathered:

Companies	IoE/IoT Integration Index	Result
Amazon	(1 / 1) x 100	100
Nestle	(1 / 1) x 100	100
Arla	(1 / 1) x 100	100
Mondelez International	(1 / 1) x 100	100
Dundee Precious Metals	(1 / 1) x 100	100
UPS	(1 / 1) x 100	100
Johnson & Johnson	(1 / 1) x 100	100

Table-4: IoE/IoT Integration Index (Self-made).

AI Integration Level

The level of AI integration in logistics for each company is as follows:

- High Integration: Companies extensively use AI for various logistics processes.
- Medium Integration: Companies use AI for specific logistics tasks or have started implementing AI in their logistics operations.

- Low Integration: Companies have limited or no AI implementation in logistics.

Based on the information gathered:

Companies	Integration Level	Integration Area
Amazon	High Integration	AI is used for supply improvement, demand forecasting, delivery route optimization, etc.
Nestle	Medium Integration	AI leveraged for analytics and network optimization
Arla	Medium Integration	AI used for operational planning and execution
Mondelez International	High Integration	AI/ML and cloud-based IoT solutions for advanced warehousing and transport management
Dundee Precious Metals	Low Integration	AI primarily used in mining operations and safety, not in logistics
UPS	High Integration	AI-powered system "ORION" for route optimization
Johnson & Johnson	Medium Integration	AI used for logistics analytics and case management

Table-5: AI Integration Level (Self-made).

IoE/IoT Integration Level

The level of IoE/IoT integration in logistics for each company is as follows:

- High Integration: Companies fully utilize IoE/IoT technologies across various logistics functions.

- Medium Integration: Companies use IoE/IoT for specific logistics processes or have partial implementation.
- Low Integration: Companies have minimal or no IoE/IoT adoption in logistics.

Based on the information gathered:

Companies	Integration Level	Integration Area
Amazon	High Integration	IoT is used for real-time tracking, monitoring, and smart management of warehouses.
Nestle	High Integration	IoT is used for supply chain traceability and process optimization and for installing state-of-the-art digital technology such as IoE.
Arla	High Integration	IoE is used for fleet management and visibility.
Mondelez International	High Integration	IoT solutions for advanced warehousing and product tracking.
Dundee Precious Metals	High Integration	IoE used for real-time tracking and safety improvements in mining operations
UPS	High Integration	IoE technologies on trucks and shipments for real-time updates

Johnson & Johnson	High Integration	IoT is used for tracking and tracing products throughout the supply chain

Table-6: IoE/IoT Integration Level (Self-made).

Discussion

Various aspects of business, including manufacturing, retail, and supply chain management, enable predictive maintenance, quality control, personalized customer experiences, and data-

driven decisions have been revolutionized by IoE and AI. The qualitative analysis covers the combination of AI and IoT/IoE in the logistics operations of other companies. Amazon uses AI for predicting customer demand and optimizing delivery

lines and IoT/IoE is engaged for real-time tracking and observation of shipments, securing

efficient supply chain operations. Nestlé used predictive analytics and robotics energy by AI for

supply chain optimization, utilization, automation so on and IoT helps in material tracking and

traceability throughout the supply and manufacturing processes. Arla uses AI-based ORTEC Routing and Dispatch for operational planning, and IoT is imposed through the AddSecure Verilocation platform, ensuing full fleet visibility and precision in data capturing, thereby enhancing logistics accuracy. Mondelez International uses AI/ML and cloud-based IoT solutions for realistic warehousing and transport management, optimizing routes, and evaluating product quality in real time. Dundee Precious Metals involves AI in mining operations and security but it has yet to fully combine AI in its logistics region. However, IoT is already used to share real-time information and track miners and vehicles; locations, thereby improving safety and automating building controls. UPS implements the AI-powered ORION system to efficient delivery lines and increment efficiency, and IoT technologies on trucks and shipments give actual updates for enhanced customer satisfaction. Johnson & Johnson implements image-based AI algorithms for logistics and IoT to optimize logistics networks and track products throughout the supply chain.

As companies move forwards with Industry Revolution 5.0, the integration of these technologies in reverse logistics can keep the promise of revolutionizing product returns, refurbishment, and recycling as well as provide them with more effectiveness and sustainability. It is sure that combination of AI and IoE enables end-to-end visibility, combination, and intelligent decision-making, driving process utilization and customer satisfaction. The integration of IoE and AI represents a powerful synergy for actual insights, data-driven decision-making, and mechanism in business operations. Both of the data analyses showcase that combination of IoE and AI in reverse logistics can bring revolution in processes such as product returns, refurbishment, recycling, and disposition, enhancing efficiency, reducing waste, and improving customer experience. AI enforces IoE in reverse logistics through intelligent decision-making and automation and aids in determining demand patterns, optimizing inventory management, and increasing reverse logistics lines.

Based on the above qualitative and quantitative analysis of the application of AI and IoE/IoT in logistics for different companies following insights and implications can be derived for the future of reverse logistics:

- The analysis shows that many companies have already integrated AI and IoE technologies into their logistics operations to enhance efficiency, visibility, and real-time decision-making. This indicates that the integration of these technologies in logistics is a well-established practice, which can serve as a foundation for future implementation in reverse logistics.
- Since AI and IoE technologies have already demonstrated their effectiveness in improving logistics, it suggests that similar benefits can be realized by integrating them into reverse
- The IoE Integration Index highlights that while some companies have fully integrated IoE technologies into their logistics operations, others are still in the early stages or have focused more on IoT technologies. This implies that for reverse logistics to fully harness the benefits of IoE, companies should aim for complete integration rather than limited adoption (Dayo-Olupona et al., 2020).

- The companies with full IoE integration demonstrate the importance of real-time data tracking, monitoring, and automation in logistics. These capabilities become even more critical in reverse logistics, where efficient management of returns, repairs, and product disposition depends on real-time visibility and data exchange (Kongar et al., 2015).
- The integration of AI and IoE in logistics signifies the readiness of companies to embrace Industry 4.0 technologies. This forward-thinking approach is essential in preparing for the next wave of industrial advancement, Industrial Revolution 5.0.

Looking forward, the future of IoE and AI in reverse logistics is enlighted. Advancements in edge computing, 5G connectivity, and machine learning algorithms will further increase the strength of both technologies (Wang et al., 2020). It will enable more sophisticated, autonomous, and efficient reverse logistics processes.

Potential Challenges in Integrating AI and IoE in Reverse Logistics

The integration of IoE and AI in reverse logistics shows great promise. But several challenges must be addressed.

One crucial concern regarding AI is the requirement for high-quality and clean data. AI algorithms heavily rely on data quality, and any inaccuracies or biases in the data may lead to erroneous conclusions and decisions (Ntoutsi et al., 2020). The complexity of AI systems and the need for specialized expertise also present a barrier to entry for some organizations (Cockburn et al., 2018). The lack of skilled AI professionals may limit widespread adoption and successful implementation. Besides, ethical considerations arise when AI is used in decision-making processes which potentially affects human resources and supplier relationships (Brendel et al., 2021). As AI continues to reshape supply chain management, addressing these critical issues will be imperative to ensure successful and responsible AI integration.

IoE also includes data security and privacy concerns as increased connectivity increases the risk of cyber threats and unauthorized access (El Khaddar and Boulmalf, 2017). The vast amount of data generated by IoE devices necessitates robust data management strategies to ensure data

integrity and relevance (AlSuwaidan, 2019). Moreover, interoperability issues among diverse IoT devices which are also present in IoE devices and platforms can hinder seamless integration and create complexity for supply chain stakeholders (Haddud et al., 2017).

Overall, data security and privacy concerns, interoperability issues among diverse IoE devices, and the need for skilled personnel proficient in AI implementation are some of the key challenges faced by businesses.

Limitations and Future Scope

The study presents compelling insights, but there are limitations too. The reliance on secondary data sources could introduce bias and inaccuracies. The scope of analyzed companies may limit generalizability. Despite these constraints, this study illuminates a pathway for future exploration. Industry-specific AI and IoE/IoT applications in reverse logistics await deeper scrutiny. It tailors solutions to diverse sectors. Ethical dimensions, such as data privacy and labor impacts, warrant investigation. Coping technological progress with eco-sustainability could drive greener logistics practices. Navigating the evolving regulatory landscape for these technologies presents a crucial area for research. As this study ignites the torch of inquiry, it invites scholars to uncover the intricate interplay between innovation and logistics as well as shape the trajectory of future research and propelling the logistics domain into uncharted yet promising territories.

Conclusion

This study highlights the dynamic connection between Artificial Intelligence (AI) and the Internet of Everything/Internet of Things (IoE/IoT) in logistics, particularly focusing on their role in reverse logistics for Industrial Revolution 5.0. The analysis of both qualitative and quantitative data indicates a noticeable trend: the increasing use of AI and IoE/IoT in logistics across various industries. AI-driven functions like optimizing delivery routes, demand prediction, and real-time tracking have become integral to modernizing logistics. The study also emphasizes how AI and IoE/IoT integration shapes reverse logistics and enhances supply chain operations through predictive analytics, robotics, and real-time tracking. The varying levels of integration readiness offer insight for companies looking to improve their reverse logistics strategies ahead of Industrial

Revolution 5.0. The reiteration of our findings encapsulates more than statistical outcomes; it encapsulates the spirit of innovation and progress. this study offers a glimpse into the future of supply chain management by encapsulating the potential for optimizing reverse logistics processes through the synergy of AI's predictive prowess and IoE/IoT's real-time insights. It envisions warehouses pulsating with digital intelligence, trucks connected seamlessly through digital webs, and customers experiencing unprecedented satisfaction through precision and speed. Ultimately, this study underscores the practicality and desirability of AI and IoE/IoT integration in contemporary logistics particularly in reverse logistics contexts. Most importantly it offers a foundation for using these technologies for innovation and efficiency in the face of upcoming industrial advancements. So it’s not just a conclusion, but a new beginning. A beginning that urges businesses to embrace change, to harness the potential of AI and IoE/IoT, and to embark on a journey where reverse logistics are not just transformed, but reborn.

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Appendix

Companies	Use of AI	Use of IoT/IoE
Amazon	Amazon employs AI to enhance supply operations and analyze data, automating tasks like predicting customer demand, managing product availability, optimizing delivery routes, and personalizing customer communication. This AI-driven approach ensures efficient one-day delivery (Eitel-Porter, 2021; Chan et al., 2022).	Amazon uses IoT through AWS Lambda to process incoming telemetry, update vehicle status, and manage data for Amazon Locations. The IoT-powered system aids warehouse management, with computers guiding optimal routes and IoT devices assisting logistics managers in locating products like ice cream for prompt delivery (Engdahl, 2022).
Nestle	Nestle utilizes AI, harnessing SAS analytics for minimizing inventory issues and enhancing supply chains. Predictive analytics and robotics aid in factory automation and supply chain traceability (Nestlé, 2023).	IoT is integrated to enhance sustainability, logistics, and production, employing sensors for tracking materials and optimizing critical processes, and installing state-of-the-art digital technology such as IoE that will accelerate improvement in sustainability, logistics, and production capacity. (Creasey, 2022).
Arla	Arla employs AI-based ORTEC Routing and Dispatch for operational planning, integrating it with SAP and mobile solutions for accurate real-time planning (ORTEC, 2023)	For IoT, Arla partners with AddSecure Verilocation, benefiting from customizable IoT-enabled fleet management that improves precision and eliminates human

		errors in logistics (AddSecure, 2022).
Mondelez International	Mondelez International implements AI/ML and cloud-based IoT solutions for optimizing warehouse and transport management. These technologies enhance route planning and vehicle load utilization, while digital track and trace ensure real-time product monitoring (Rana, 2022).	
Dundee Precious Metals	Dundee Precious Metals uses AI in mining operations but not logistics (Person, 2020).	IoE has enabled real-time sharing of critical information, including miner and equipment updates, enhancing safety and monitoring vehicle status (Iscoop, 2021).
UPS	UPS employs AI through its "ORION" system for route optimization, intelligently selecting efficient routes for drivers based on package details (Holland et al., 2017).	UPS utilizes IoE for real-time updates on shipments and trucks, enhancing delivery efficiency (Kanade, 2022).
Johnson & Johnson	Johnson & Johnson's Advance Case Management platform employs AI algorithms to digitize processes, reducing logistics touchpoints (Shapiro, 2023).	Johnson & Johnson leverages IoT for tracking and tracing products across the supply chain (Kanade, 2022). It is transitioning towards IoE to develop self-driving systems that generate accurate production forecasts. This aids in optimizing logistics networks and significantly reducing cycle time (Ackerman and Krigsman, 2019).

Table-1: AI and IoT/IoE integration in logistics (Self-made).

Aspect	Total Companies	Number of Companies using AI or IoE/IoT	Percentage
Using AI in Logistics	7	6 (Amazon, Nestle, Arla, Mondelez International, UPS, Johnson & Johnson)	85.71%
Using IoE/IoT in Logistics	7	7 (Amazon, Nestle, Arla, Mondelez International, Dundee Precious Metals, UPS, Johnson & Johnson)	100%

Table-2: Percentage Calculation for AI and IoT/IoE (Self-made).

Companies	AI Integration Index	Result
Amazon	(2 / 2) x 100	100
Nestle	(2 / 2) x 100	100
Arla	(1 / 1) x 100	100
Mondelez International	(1 / 1) x 100	100
Dundee Precious Metals	(0 / 1) x 100	0
UPS	(1 / 1) x 100	100
Johnson & Johnson	(1 / 1) x 100	100

Table-3: AI Integration Index (Self-made).

Companies	AI Integration Index	Result

Amazon	(1 / 1) x 100	100
Nestle	(1 / 1) x 100	100
Arla	(1 / 1) x 100	100
Mondelez International	(1 / 1) x 100	100
Dundee Precious Metals	(1 / 1) x 100	100
UPS	(1 / 1) x 100	100
Johnson & Johnson	(1 / 1) x 100	100

Table-4: IoE/IoT Integration Index (Self-made).

Companies	**Integration Level**	**Integration Area**
Amazon	High Integration	AI is used for supply improvement, demand forecasting, delivery route optimization, etc.
Nestle	Medium Integration	AI leveraged for analytics and network optimization
Arla	Medium Integration	AI used for operational planning and execution
Mondelez International	High Integration	AI/ML and cloud-based IoT solutions for advanced warehousing and transport management
Dundee Precious Metals	Low Integration	AI primarily used in mining operations and safety, not in logistics
UPS	High Integration	AI-powered system "ORION" for route optimization
Johnson & Johnson	Medium Integration	AI used for logistics analytics and case management

Table-5: AI Integration Level (Self-made).

Companies	Integration Level	Integration Area
Amazon	High Integration	IoT is used for real-time tracking, monitoring, and smart management of warehouses.
Nestle	High Integration	IoT is used for supply chain traceability and process optimization and it is installing state-of-the-art digital technology such as IoE.
Arla	High Integration	IoE is used for fleet management and visibility.
Mondelez International	High Integration	IoT solutions for advanced warehousing and product tracking.
Dundee Precious Metals	High Integration	IoE used for real-time tracking and safety improvements in mining operations
UPS	High Integration	IoE technologies on trucks and shipments for real-time updates
Johnson & Johnson	High Integration	IoT is used for tracking and tracing products throughout the supply chain

Table-6: IoE/IoT Integration Level (Self-made).