TPM Vol. 32, No. R2, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

DIGITAL TRANSFORMATION IN THE LOGISTICS INDUSTRY: AN EVIDENCE-BASED SYNTHESIS OF LOGISTICS ACTIVITY

BHARIS HONGSAKUL
PH.D. CANDIDATES, DEPARTMENT OF BUSINESS ADMINISTRATION, KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG, PRINCE OF CHUMPHON CAMPUS, THAILANDEMAIL: 66206013@kmitl.ac.th

CHANYAPHAK LALAENG, PH.D.
ASSISTANT PROFESSOR, PH.D., DEPARTMENT OF BUSINESS ADMINISTRATION, KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG, PRINCE OF CHUMPHON CAMPUS, THAILAND.
EMAIL: chanyaphak.la@kmitl.ac.th

APINYA INGARD, PH.D.
ASSISTANT PROFESSOR, PH.D., FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY, SILPAKORN UNIVERSITY, THAILAND, EMAIL: ingard_a@su.ac.th

ABSTRACT
This review synthesizes evidence on how digital technologies transform nine cores logistics activities: demand forecasting and planning; customer service and support; logistics communications and order processing; purchasing and procurement; materials handling and packaging; facility site selection, warehousing, and storage; inventory management; transportation; and reverse logistics. Structured searches of studies published between 2015 and 2025 identify empirical and rigorous simulation research reporting quantitative outcomes for efficiency, accuracy, service level, resilience, and sustainability. Findings are organized by activity and mapped to the most relevant technologies. Artificial intelligence and machine learning, IoT and RFID, cloud computing, big data analytics, and robotics and automation yield consistently positive effects when aligned with activity requirements: higher forecast accuracy and service performance; shorter order cycles with fewer errors; improved inventory turnover and lower holding costs; and better on-time delivery with reduced fuel use and emissions. AR/VR, blockchain, and digital twins exhibit emerging to medium–high impact in training, traceability, and network or warehouse optimization, respectively. Adoption remains constrained by high upfront investment, skill shortages, process and culture change, cybersecurity and privacy risks, and end-to-end data integration across partners. An activity–technology roadmap is offered to guide prioritization, sequencing, and scale-up, with implications for managers and policymakers in Asian markets.
Keywords: Digital Transformation, Logistics Industry, Logistics Activities

I. INTRODUCTION

Over the past decade, the world has fully entered the era of digital transformation, resulting in the need for many industries to adapt in order to ensure survival and achieve sustainable growth (Manastrong et al., 2023). Particularly in the logistics sector, which is considered the "lifeblood" of the economy and supply chain systems at both national and global levels, adaptation has become crucial. The expansion of the e-commerce market, the rapidly changing expectations of consumers, and the intensification of competition are all factors that have inevitably driven the logistics industry to transform its operational processes towards digitalization (Nguyen, 2020; Al Mashalah et al., 2022; Adeniran et al., 2024).
Digital transformation in the logistics sector is not merely the adoption of new technologies; rather, it represents a structural change that encompasses the design of work processes, the management of resources, strategic decision-making, and the real-time responsiveness to customer demands (Demir et al., 2020; Attah et al., 2024). Key technologies that play a significant role, such as the Internet of Things (IoT), Artificial Intelligence (AI), Robotics and Automation, and Blockchain, possess the potential to enhance the agility, accuracy, and efficiency of logistics systems, enabling them to remain competitive in the digital economy era. (Raja, 2021; Khan et al., 2023; Paramesha et al., 2024)
Although a considerable number of studies have examined digital transformation within the overall logistics system, in-depth investigations remain limited, specifically on each logistic activity. According to the Logistics Office, Department of Primary Industries and Mines, Ministry of Thailand (2015), and Hongskul

& Chuaychoo (2024), logistic activity refers to the execution of various activities aimed at satisfying customer requirements at an appropriate cost. The 9 logistics activities are: 1. Demand Forecasting and Planning, 2. Customer Service and support, 3. Logistics Communications and Order Processing, 4. Purchasing and Procurement, 5. Materials Handling and Packaging, 6. Facilities Site Selection, Warehousing, and Storage, 7. Inventory Management, 8. Transportation, and 9. Reverse Logistics. In particular, studies that analyze the impact of the application of digital technologies in each individual logistics activity in a disaggregated manner in order to clearly illustrate the distinct roles and values of each type of technology remain scarce. Nevertheless, the research gap also reflects that there is a very limited number of studies that focus on comparative analyses of logistics activities before and after the digital transformation, particularly in terms of efficiency, cost, operational time, and customer satisfaction. Furthermore, there is a lack of integrated perspectives that connect the dimensions of technology, processes, and the overall organizational impacts.
This study is significant not only for reviewing the concepts and technologies involved but also for addressing the knowledge gap concerning the transformation of key logistics activities resulting from the application of digital technologies. These insights will assist businesses, government agencies, and researchers in making strategic decisions, investment plans, and policy formulations that align with the future of digital logistics. Understanding digital transformation and selecting appropriate technologies are essential for each industry sector (Nugroho et al., 2023). In particular, the logistics industry faces challenges in enhancing efficiency, reducing costs, and responding swiftly to market demands. Therefore, this article aims to review the application of digital transformation in the logistics industry, with a specific focus on "Logistics Activities" as a guideline for the development and growth of the industry in the future.

II. METHODOLOGY

2.1 Scope and Research Questions

This review examines the performance implications of digital technologies across nine logistics activities: (1) demand forecasting and planning, (2) customer service and support, (3) logistics communications and order processing, (4) purchasing and procurement, (5) materials handling and packaging, (6) facilities site selection, warehousing, and storage, (7) inventory management, (8) transportation, and (9) reverse logistics. The analysis addresses three questions: which technologies improve which KPIs within each activity; through which mechanisms and under what conditions such effects arise; and how adoption and scaling should be prioritized.

2.2 Information Sources and Search Strategy

English-language studies published between 2015 and 2025 were identified from general bibliographic databases (e.g., Scopus, Web of Science) and engineering-oriented sources (e.g., IEEE Xplore, ACM Digital Library). Search strings combined three constructs—logistics activities, digital transformation terms, and technology clusters (AI/ML, IoT/RFID, cloud, big data/analytics, robotics/automation, AR/VR, blockchain, digital twins)—and were supplemented by backward and forward citation chasing.

2.3 Eligibility Criteria

Included studies comprised empirical or rigorous simulation designs reporting quantitative outcomes for at least one KPI dimension: efficiency (time/cost), quality/accuracy, service level, resilience, or sustainability. Each study examined at least one target technology in the context of one or more of the nine logistics activities. Conceptual-only works, non-logistics contexts, and studies without measurable outcomes were excluded.

2.4 Study Selection and Reliability

Records were de-duplicated and screened in two stages (title/abstract, then full text) by two independent reviewers. Discrepancies were resolved through discussion, with escalation to a third reviewer as required. Inter-rater reliability was documented using Cohen's κ to evidence screening consistency.

2.5 Data Extraction and Coding

A structured template captured bibliographic details, sector/region, logistics activity, technology cluster, outcome metrics/KPIs, effect direction (positive, neutral/mixed, negative), study design, and quality indicators. Metrics were normalized to a consistent interpretive frame (e.g., reductions in time/cost and increases in accuracy/service level denote improvement). Variables were organized under a taxonomy of activity × technology × KPI × context (context reflecting organizational and environmental conditions).

2.6 Synthesis Strategy

Given heterogeneity in measures and designs, a structured narrative synthesis was undertaken and supported by semi-quantitative procedures:

- effect-direction coding and vote counting within each technology × activity × KPI cell;
- evidence mapping via heatmaps to visualize coverage and consistency;

- best-evidence synthesis assigning greater descriptive weight to higher-quality, transparently reported studies;
- a maturity–impact matrix positioning technologies by industry readiness against realized performance impact to inform adoption sequencing; and
- subgroup/moderator analysis, using a TOE lens (Technology–Organization–Environment), to explore variation by firm size, digital readiness, sector, region, and data/interoperability maturity.

Where subsets of studies reported commensurate metrics, simple standardized contrasts were used to corroborate effect direction and magnitude.

2.7 Quality Appraisal and Robustness Checks

Study quality was assessed using design-appropriate checklists and categorized as high, medium, or low. Sensitivity analyses re-synthesized findings after excluding low-quality studies, compared patterns across sectors/regions, and tested the stability of effect-direction coding where alternative metric codings were plausible.

2.8 Criteria for Classifying Positive Effects

An effect was classified as positive when the primary study reported statistical significance in the expected direction or when the observed change exceeded a minimally practically important difference defined within the study/domain. In the absence of such thresholds, conservative, context-aware judgments were applied, triangulating across multiple KPIs where available.

2.9 Methodological Limitations

The synthesis privileges direction and consistency of evidence over pooled effect sizes when metrics are non-commensurate. Findings may therefore be influenced by reporting variability and uneven coverage across activities or regions. These risks were mitigated through transparent coding, quality-weighted synthesis, and multiple robustness checks.

Following the evidence synthesis outlined above, this study presents the findings in a structured narrative organized around three headings: (1) Technologies Related to Digital Transformation in the Logistics Industry; (2) Application of Digital Transformation in Key Logistics Activities; and (3) Challenges of Digital Transformation in Logistics for Competitive Advantage and Sustainable Growth. As set out in Section 5 (Results), each heading integrates activity-level insights with technology–activity–KPI linkages and contextual considerations, clarifying where impacts are most salient and how they can be operationalized in practice.

III. RESULTS

3.1 Technologies Related to Digital Transformation in the Logistics Industry

3.1.1 Internet of Things (IoT)

The Internet of Things (IoT) is a technology that enables objects, such as tools, devices, or products, to connect to the internet and exchange data automatically without human intervention (Ait, 2021). In the logistics industry, IoT facilitates processes such as real-time product tracking, making them faster and more transparent. The immediately accessible data allow for quick and accurate decision-making, reducing errors and delays in transportation, thereby saving both time and costs. The use of IoT also enhances transportation safety as it facilitates the tracking of the status of goods during transit, enabling immediate corrective actions in the event of accidents or abnormalities. Moreover, IoT supports sustainable logistics processes by providing visibility into data, which helps reduce waste and allows more efficient use of resources, benefiting the environment (Tran-Dang et al., 2022; Ding et al., 2023).

Furthermore, the use of IoT enhances service transparency, as customers can track the status of their purchased goods at any time, which fosters confidence and trust in the service. For example, the use of sensors in cargo trucks that transmit data on temperature, humidity, or GPS to a central system enables managers to monitor the transportation process in real time (Ravi Chandra et al., 2024). In summary, the use of IoT in the logistics industry not only enhances operational efficiency but also strengthens safety, transparency, and sustainability. It helps address challenges and build customer trust, enabling the logistics industry to develop sustainably in the long term.

3.1.2 Artificial Intelligence (AI)

The application of Artificial Intelligence (AI) in the logistics industry is becoming a crucial tool for enhancing efficiency, as this industry must handle vast amounts of data and make critical decisions to respond to customer demands swiftly and accurately (Chen et al., 2024). One of the applications of AI is Big Data analysis and intelligent decision-making. AI helps process data from various sources, such as transportation data, product status tracking, and data from sensors in machinery and vehicles, enabling more accurate analysis and better decision-making. AI assists in selecting the most efficient transportation routes, calculating transportation costs, or forecasting product demand, which enables operators to improve transportation planning, reduce the risks of stock shortages, or minimize excess inventory (Woschank et al., 2020).

AI also helps automate the transportation process by utilizing robots and automation systems in warehouse management and transportation. This reduces time and increases operational efficiency. Additionally, AI can adjust transportation processes automatically when problems or abnormalities occur. It can send alerts when machinery or vehicles experience issues and adjust processes to align with the arising situation. Another benefit of AI is cost reduction and efficiency improvement. AI can calculate transportation costs for various routes and assess risks associated with transportation errors, such as delays or product loss, which helps operators plan and make decisions more effectively (Adesoga et al., 2024; Sodiya et al., 2024).

3.1.3 Machine Learning (ML)

Machine Learning (ML) also plays a significant role in the logistics industry by predicting and forecasting future product demand or transportation volume. ML utilizes historical transportation data, such as the quantity of goods shipped during specific periods or customer sales data, to create models that can more accurately predict future demand. This helps companies prepare in advance and adjust their management processes in a timely manner, reducing issues related to stock shortages or excess inventory (Ozkan-Ozen et al., 2025).

Another important function of Machine Learning (ML) is route optimization and resource management. ML can analyze historical traffic and weather data to determine the most efficient transportation routes for goods delivery. This significantly reduces transportation time and costs. For example, it can be utilized to avoid congested routes or adjust routes based on adverse weather conditions (Behrooz et al., 2022).

ML can also be used to detect anomalies and improve operations by monitoring machinery or vehicles with issues, or by checking products that may be damaged during transportation. The ML system learns from the collected data and alerts relevant stakeholders to take corrective actions or adjust processes promptly. It can also be applied to automatically optimize the operation of transportation systems or warehouses when problems or irregularities are detected (Jaramillo-Alcazar et al., 2023). Lastly, the use of ML can enhance inventory management efficiency by analyzing and predicting the demand for products at different times. ML is now routinely used to analyze order data or product turnover within the warehouse. This helps reduce storage costs and mitigate product shortages in the market (Pasupuleti et al., 2024).

3.1.4 Robotics and Automation

Robots and automation are technologies that help improve operational efficiency and reduce human errors. They play a crucial role in enhancing various processes, from inventory storage to transportation and data management. In the logistics industry, robots can be utilized in several areas, such as lifting, transportation, sorting products, quality inspection, and packaging (Radivojević & Milosavljević, 2019).

Robots used in the logistics industry are designed to be suitable for tasks that require precision and speed. For example, Automated Guided Vehicles (AGVs) are robots that can move along predefined paths automatically to transport goods from one point to another without human intervention (Khan et al., 2022).

Automation in the logistics industry refers to the use of computer systems and various technologies to perform tasks that were previously carried out by humans. This includes warehouse management, product delivery, and coordination between different processes within the supply chain. An example is Automated Warehouse Systems, which utilize technology to organize and store products using robots or machines that can operate 24 hours a day (Ferreira & Reis, 20233).

The use of robotics and automation in the logistics industry significantly reduces time and operational costs. For example, the application of robots in the packaging process or the use of automated systems for sorting products in warehouses enhances the speed and accuracy of these processes (Ferreira & Reis, 20233). Furthermore, the use of robotics and automation enables logistics companies to adapt to the growing demands of the industry. Complex tasks that require high precision can be performed more efficiently, labor costs can be reduced, and the ability to adjust quickly to market changes can be enhanced (Khan et al., 2022).

3.1.5 Cloud Computing

Cloud computing is a technology that facilitates the storage and processing of data on servers accessible from anywhere, making data management in the logistics industry more convenient and flexible. (Ten Hompel et ai., 2015). The use of cloud computing enables companies to access information about products, transportation, or various processes at any time, without the need to store data exclusively within the organization's internal systems. Collaboration between teams or service providers becomes easier and faster through online connections that allow real-time access to information (Kanimozhi Suguna & Nanda Kumar, 2019). A clear example of cloud computing application in logistics is the use of cloud-based Warehouse Management Systems (WMS). This allows inventory data, storage processes, and goods movement to be accessed from anywhere. This enables managers or employees to accurately and timely monitor the status of goods, product movement, and inventory orders. This system improves warehouse management efficiency, reduces errors from manual operations, and simplifies inventory planning and decision-making (Plazibat et al., 2024).

Cloud computing thus functions as a tool that helps companies in the logistics industry reduce IT management costs and enhance operational flexibility. By providing easy and quick access to data and various systems, all information can be stored and processed in the cloud. This enables timely decision-making in logistics processes, while also allowing for flexibility in responding to the ever-changing market demands (Alnaimat et al., 2024).

3.1.6 Big Data and Analytics

The use of Big Data and Analytics enables companies in the logistics industry to make more efficient and accurate decisions. By collecting data from multiple sources, such as transportation information, inventory levels, and customer demand, this technology allows for the analysis of trends, forecasting, and the improvement of various operational processes (Aubakirova, 2024). The use of Big Data helps companies better understand customer behavior and demand, enabling them to plan and make strategic decisions more effectively. A clear example of Big Data application is Supply Chain Analytics, which gathers data from various sources to provide a comprehensive view of product movement and transportation. By analyzing data from transportation, inventory, and customer demand, companies can forecast future needs, allowing them to adjust inventory management and transportation processes quickly and efficiently to meet customer demand (Perevozova et al., 024). Another important example is the use of Big Data to optimize transportation efficiency. By analyzing transportation routes and calculating the best delivery times, gathering data from GPS systems and various sensors enables the calculation of the most efficient routes. This helps reduce transportation time and operational costs. This data analysis also helps predict potential issues during transportation, such as traffic congestion or adverse weather conditions. This enables timely decision-making to adjust routes appropriately (Ogunkan & Ogunkan, 2025).

The use of Big Data and Analytics allows logistics companies to enhance operational agility, streamline processes, and better respond to customer demands. It also helps reduce costs and increases competitiveness in a rapidly changing market.

3.1.7 Augmented Reality (AR) and Virtual Reality (VR)

Augmented Reality (AR) and Virtual Reality (VR) technologies are playing an increasingly important role in the logistics industry by creating new experiences in training, planning, and site inspections across various processes. For example, in employee training or warehouse inspections, both AR and VR contribute to enhancing operational accuracy and efficiency in logistics operations (Remondino, 2020). One prominent application of these technologies is employee training, where VR is used to simulate real working conditions in warehouses. This includes training on equipment use or managing transportation processes. Employees can practice their skills in a virtual environment, reducing the cost and time spent on physical training. Furthermore, this virtual experience enables them to gain confidence and acquire the necessary skills to handle real-world situations effectively (Lagorio et al., 2022).

In the scope of warehouse inspections, Augmented Reality (AR) has proven to be a valuable tool. By utilizing AR, warehouse managers can view real-time data about products or stock statuses through AR displays on mobile devices or AR glasses. This allows for precise and timely tracking of goods movements within the warehouse, whether it's checking stock levels, arrangement statuses, or other product-related information. The AR data display helps warehouse managers make quick and effective decisions, enhancing operational efficiency and accuracy (Jumahat et al., 2023). The use of AR and VR not only enhances work efficiency but also helps reduce errors and increase safety in logistics operations in the industry by making training and data inspections more effective and realistic (Simon, 2024).

3.2 Application of Digital Transformation in Key Logistics Activities

The application of digital technologies in key logistics activities is crucial for enhancing efficiency and reducing operational costs. This enables logistics service providers to meet customer satisfaction effectively. According to the Logistics Office, Department of Primary Industries and Mines, Ministry of Industry of Thailand (2015) and Hongsakul & Chuaychoo (2024), the key logistics activities are divided into nine activities as follows:

3.2.1 Demand Forecasting and Planning

Digital technologies play a vital role in the development of demand forecasting and production planning by aiding in the collection of data from various sources, such as sales data, customer behavior, market trends, and external factors like economic changes or seasonal shifts. The use of Big Data Analytics and Machine Learning tools improves the accuracy of forecasting future demand (Ramya et al., 2024).

• Big Data Analytics: The use of Big Data Analytics allows the processing of large volumes of data from various sources efficiently. It helps uncover patterns, relationships, and trends in customer behavior that might not be noticeable through traditional methods. This enables a better understanding of customer demands and the ability to forecast potential changes in the future (Rofi'I, 2023).

• Machine Learning and Predictive Modeling: Machine Learning is a technology that learns from past data to create models for predicting future demand. By utilizing algorithms that learn and adapt to new data, the accuracy of the forecasts improves over time. For example, it can predict when demand for products will rise during festive or seasonal periods (Zohdi et al., 2022).

• Improved Accuracy and Responsiveness: With the adoption of digital technologies, demand forecasting has become more accurate, which helps reduce the risks associated with overproduction or underproduction. This, in turn, assists in better production planning and inventory management (Verma, 2024).

• Real-time Adjustments: Digital technologies enable real-time monitoring of customer demand and inventory status. When changes occur in demand or other influencing factors, production and distribution plans can be swiftly adjusted (Fatorachian et al., 2025).

Demand forecasting is a crucial tool that helps businesses manage their inventory efficiently, reducing storage costs and preventing issues like stockouts or overstocking. It ensures that products are available to meet customer demand at the right time. This results in customers receiving fast service that meets their expectations, which contributes to building long-term satisfaction and positive relationships. Accurate forecasting also reduces waste in production processes and allows for more efficient resource utilization (Immadisetty, 2025; Shoaib et al., 2025).

3.2.2 Customer Service and Support

The use of digital technologies, such as Customer Relationship Management (CRM) systems and Artificial Intelligence (AI), has played a significant role in improving customer service and various support activities. These technologies enable quicker and more efficient customer responses, which enhances customer satisfaction and fosters long-term positive relationships between customers and businesses (Chatterjee & Chaudhuri, 2023).

• The Use of Customer Relationship Management (CRM) Systems: CRM systems help businesses systematically and comprehensively store customer data, including contact information, purchase history, preferences, and specific customer needs. This allows businesses to track order statuses and gain a better understanding of customer demands. Additionally, CRM systems enable businesses to offer promotions or products that align with customers' interests, thus strengthening relationships and enhancing customer satisfaction (Hossain et al., 2024).

• The Use of AI and Chatbots for Customer Interaction: AI and chatbots are employed to analyze customer data and provide accurate responses to complex inquiries. By learning from past communication histories or previously provided data, they can improve the relevance and accuracy of their responses. Chatbots also handle general inquiries about order statuses, product details, or services without the need for human intervention, reducing waiting time and enhancing customer convenience (Ngai et al., 2021).

• The Use of Automation in Order Management: Automation technology enhances order management efficiency by integrating with CRM systems to automate processes such as order confirmation, shipping cost calculation, and inventory management. This reduces errors and increases the speed of service (Ugbebor et al., 2024).

The use of AI, Chatbots, and CRM systems in customer service enhances the speed and accuracy of responses, allowing customers to receive immediate service without delays. Moreover, automation systems help reduce the time taken for order processing and enable 24/7 service without the need for human staff (Spring et al., 2022). This not only increases customer convenience but also improves customer satisfaction, making customers more likely to revisit and repurchase in the future.

3.2.3 Logistics Communication and Order Processing

The use of cloud computing allows businesses to store data related to orders, inventory, and customer information in the cloud. This enables all team members to access the same data simultaneously, without relying on specific users or specialized devices (Alnaimat et al., 2024).

• Data Management in Cloud Systems: Real-time access to data allows for immediate updates whenever there are changes in order status or when corrections are needed. This reduces errors from incorrect or delayed communication. Furthermore, cloud systems enable all parties involved in the logistics process (from order-taking employees to customer service teams) to track the status of orders simultaneously. This tracking capability ensures that customer inquiries can be answered quickly with accurate information (Temjanovski et al., 2021).

• Communication Between Teams and Deliveries: The Cloud system facilitates the connection of data among various teams involved in the order fulfillment process, such as the sales, warehouse, and transportation teams. This makes coordination and communication between teams more convenient and efficient. The updated and shared data within the same system allows all teams to work together seamlessly without concerns about miscommunication or missing information. This results in a faster and smoother workflow. Clear and rapid communication within the Cloud system also helps reduce errors caused by misunderstandings or delays in conveying crucial information such as shipping details or inventory status, thereby enhancing accuracy and efficiency in operations (Zou & Jian, 2022; Sornprom, 2024).

• Collaboration with Other Applications and Digital Tools: The Cloud system can also integrate with other digital tools and applications used in logistics management, such as Warehouse Management Systems (WMS), Transportation Management Systems (TMS), or Customer Relationship Management (CRM) systems. This integration helps streamline the entire process from order reception to product delivery (Sharma & Panda, 2023).

Utilizing Cloud Computing to manage order data and facilitate communication within the logistics process enhances coordination between teams and suppliers and enables real-time order tracking. This technology reduces errors, increases operational efficiency, and ensures a quick and accurate response to customer demands.

3.2.4 Purchasing and Procurement

Digital technology plays a crucial role in enhancing transparency and efficiency in the purchasing and procurement process within the logistics industry, especially through the use of e-procurement systems. These systems allow businesses to perform purchasing tasks quickly, accurately, and transparently. The implementation of such technologies helps simplify the complex steps of supplier selection and enables purchasing decisions based on desired criteria, including both price and quality (Sarjono et al., 2024).

• Use of e-procurement systems: e-procurement systems are digital tools that facilitate the procurement process, from supplier selection to requesting quotations (RFQ) and managing orders entirely online. These systems streamline all steps, enabling businesses to request quotes and compare offers from multiple suppliers simultaneously, making it easier to select the supplier offering the best price and quality. Additionally, once a supplier is chosen, orders can be created and sent through the system immediately, eliminating the need for paper documents or delays in contact, thus improving the efficiency of the procurement process (Gurgun et al., 2024; Raghul et al., 2024).

• Supplier evaluation and selection: Digital technology enhances the transparency and efficiency of supplier selection by leveraging insights derived from transaction history, product quality, and delivery performance. The **e-**procurement system also helps compare prices and proposals from various suppliers, enabling more precise and effective decision-making. Furthermore, it creates a supplier database with performance ratings, making it easier to select high-quality suppliers (Zhu et al., 2022).

• Tracking procurement status: e-procurement systems allow real-time tracking of the order status at every stage, from order creation to delivery. This enables real-time tracking of the procurement progress. Additionally, procurement managers can instantly monitor the delivery status directly from the system, which helps in quickly addressing any issues or delays in the delivery process (Jain, 2023).

The use of e-procurement systems in the purchasing and procurement process enhances transparency, reduces errors, and improves supplier selection efficiency. Additionally, it allows for rapid and accurate tracking of procurement status, helping businesses reduce operational costs and manage orders more efficiently.

3.2.5 Materials Handling and Packaging

In the logistics industry, technologies such as automation systems and robotics play a crucial role in enhancing the efficiency of material handling and packaging operations. These technologies reduce the reliance on human labor and improve accuracy in warehouse management. The integration of these technologies helps minimize human errors and increases operational speed (Kumar & Sudarvel, 2025).

• Automation: Automation in the material handling and packaging process enhances efficiency by eliminating the need for human labor in various stages. These systems include conveyor systems, which swiftly and safely move goods to different locations, reducing time and preventing accidents caused by heavy lifting. Additionally, automated sorting systems help sort and arrange products accurately and quickly, minimizing errors and enabling continuous 24-hour operations (Li, 2024).

• Robotics: Robotics plays a key role in product handling, packaging, and warehouse management. Robots operate efficiently in high-traffic and complex environments. For example, Automated Guided Vehicles (AGVs) move products to different locations without human intervention, reducing errors and speeding up the transportation process. Additionally, robotic packaging systems can package goods quickly and accurately, selecting the appropriate packaging and working continuously 24 hours a day without fatigue (Štaffenová et al., 2023).

• Integration of Systems: The integration of robotics with the Warehouse Management System (WMS) enables seamless operations. Robots can transport and package products according to orders, with the system updating inventory and shipping information in real-time. This integration improves overall process efficiency and reduces errors (Minashkina, 2024).

The use of automation and robotics in material handling and packaging boosts operational efficiency within warehouses by reducing dependency on human labor, increasing accuracy, and accelerating processes. These technologies help minimize human errors and ensure that operations are swift and efficient.

3.2.6 Facility Site Selection, Warehousing, and Storage

Facility site selection and warehousing are crucial to the efficiency of logistics processes. Geographic Information Systems (GIS) and data analysis have become important tools in making decisions regarding the selection of factory and warehouse sites. These technologies help optimize warehouse management, reduce transportation costs, and enhance overall operational efficiency (Kang, 2020; Pour et al., 2025).

• GIS for Site Selection: GIS technology enables businesses to analyze spatial data to effectively select sites for factories or warehouses. Key factors, such as distance from production site, market accessibility, and road conditions, are taken into account. Furthermore, GIS assists in analyzing the most efficient and cost-effective transportation routes, which reduces transportation costs and enhances operational efficiency. The use of geographic data helps identify optimal locations, significantly cutting down on time and costs associated with product transportation (Feng et al., 2023).

• Data Analytics: By combining data analytics with GIS, businesses can make more informed decisions. This includes calculating transportation costs based on various site options and identifying the location that minimizes these costs. Additionally, data analytics help determine the ideal warehouse capacity, considering both current and future trends, such as the required size of the warehouse or space needed for storage (Attah et al., 2024).

• Warehouse Management: The use of technology in warehouse management enables efficient storage and movement of goods within warehouses. Warehouse Management Systems (WMS) and automation technologies help manage inventory, orders, and real-time order processing, streamlining operations (Minh, 2024).

The use of GIS and data analytics in site selection allows businesses to make optimal location decisions, reducing transportation costs and improving warehouse management efficiency. Additionally, employing technologies like WMS and automation enhances the organization and effectiveness of warehouse operations.

3.2.7 Inventory Management

Inventory management is a crucial process in the logistics industry as it directly impacts the efficiency of product storage, order management, and the reduction of storage costs. The IoT (Internet of Things) and RFID systems have become essential tools for improving inventory management processes. These technologies enable real-time inventory tracking, reduce errors from manual stock counting, and enhance the overall efficiency of inventory management (Mwakima & Osoro, 2024; Pasupuleti et al., 2024).

• IoT for Inventory Tracking: IoT technology aids businesses in accurately monitoring the status of products by using sensors and internet-connected devices to collect various data, such as temperature, humidity, or product movement. Furthermore, IoT allows for real-time monitoring of inventory within warehouses and facilitates the tracking of the movement of goods, enabling warehouse managers to predict demand and efficiently avoid stockouts or overstocking issues (Rani et al., 2024).

• RFID for Inventory Management: RFID systems enable businesses to automatically track the status and location of goods by attaching RFID tags to products or packaging. These tags communicate with RFID readers, allowing for the scanning of all items in a warehouse without handling them manually, which reduces inventory counting and verification time. RFID also enables precise tracking of goods movement within the warehouse, ensuring that storage and shipping processes are accurate (Bousselmi et al., 2024).

• Integration of IoT and RFID: The integration of IoT and RFID systems facilitates the comprehensive tracking of inventory status throughout every step, from receiving goods to shipping. IoT is used to monitor product conditions combined with RFID to track the location and movement status of products in the warehouse (Samanta & Golui, 2023).

The use of IoT and RFID in inventory management allows for accurate tracking and management of warehouse inventory, reducing errors from manual counting and improving the accuracy of inventory control. These technologies also enable real-time status checks of goods in the warehouse, facilitating immediate decisions on inventory management and helping to mitigate stock shortages or overstocking problems.

3.2.8 Transportation

Transportation is a crucial part of the logistics process that enables the movement of goods to their destination. Various technologies, such as GPS, Route Optimization Software, and Machine Learning (ML), have played a significant role in enhancing the efficiency of transportation processes. These technologies assist in calculating the optimal routes and quickly adjusting the routes in the event of delays or issues along the way (Ang et al., 2022; Tae-Woo Lee et al., 2024).

• GPS for Vehicle Tracking: GPS technology allows for real-time tracking of vehicles, providing information on their location and movement. This includes details such as the distance traveled, time spent during transportation, and estimated arrival time. Additionally, GPS can trigger alerts for special events such as route deviations or accidents, enabling faster and more accurate transportation management (Zohari & Nazri, 2021).

• Route Optimization Software: This system helps calculate and recommend the best routes for transporting goods, considering factors such as distance, time, traffic conditions, and weather. The software can determine the shortest routes to avoid congested areas or accident-prone zones. It can also adjust routes based on real-time situations, such as alerts for accidents or traffic jams, making transportation faster and smoother (Eljazović et al., 2024).

• Machine Learning for Route Prediction: Machine Learning (ML) helps predict transport routes based on historical transportation data, such as traffic conditions, distance, and travel time. ML can forecast potential issues along the route, such as weather conditions that may affect travel or areas with heavy traffic at specific times. Moreover, ML can automatically suggest the best routes and continuously improve decision-making for future transportation, ensuring maximum efficiency (Boukerche & Wang, 2020).

The use of GPS, Route Optimization Software, and Machine Learning in transportation enhances the efficiency of the process by calculating optimal routes, reducing transportation time, and tracking the status of shipments in real-time. These technologies help reduce transportation costs and improve the speed and accuracy of deliveries.

3.2.9 Reverse Logistics

Reverse logistics involves the process of returning goods and managing unsold products or items that need to be sent back to the manufacturer or distributor, including products returned by customers, and damaged or defective items. Digital technologies play a significant role in improving the efficiency of reverse logistics, particularly in tracking returns and managing products sent back by customers (Guarnieri et al., 2020; Plaza-Úbeda et al., 2020).

• Online Returns Tracking System: This system ensures that the reverse logistics process is fast and transparent, allowing customers to track the status of their returned goods conveniently. Customers can check whether the returned items have reached the returns center, are being inspected, or are undergoing condition assessments. The system enables both customers and service providers to track every step of the process, from return shipment to the processing of the return request. Additionally, the online system simplifies the return process by allowing customers to input information and monitor the status at any time, making returns more convenient and less complicated (Starostka-Patyk, 2021).

• RFID and Barcode Technology for Returns Management: When items are returned, RFID or barcode systems can quickly and accurately identify the returned products without requiring manual inspection. These technologies also help in immediately identifying the condition of the returned items, recording any damage or determining if the product is still usable. This streamlines the returns inspection process, making it more efficient and accurate (Tebaldi et al., 2023).

• AI and Big Data for Predictive Returns Management: Artificial Intelligence (AI) can analyze historical return data to predict products that are likely to be returned in the future. This helps businesses prepare more effectively for managing returns. Additionally, Big Data analytics improves the returns process by enhancing systems designed for faster and more convenient returns (Al Doghan & Sundram, 2023).

The use of various technologies, such as online returns systems, RFID, barcodes, AI, and Big Data, accelerates the reverse logistics process, reduces operational costs, and improves the overall return management process. These technologies allow businesses to track return statuses, inspect returned goods quickly, and predict future returns, ultimately increasing customer satisfaction and enhancing business operations.

The following table summarizes examples of digital transformation applications in the logistics industry based on the key logistics activities.

TABLE 1 List of digital transformation application examples in the logistics industry.

Logistic Activities	Digital Transformation Application	References
Demand Forecasting and Planning	- Big Data Analytics to analyze sales data, customer behavior, and market trends - Machine Learning using models to predict demand - Real-time Adjustments to modify plans in real-time - Improved Accuracy to reduce excessive or low inventory	Chang (2021); Zohdi et al. (2022); Rofi'I (2023); Ramya et al. (2024); Verma (2024); Fatorachian et al. (2025); Immadisetty (2025); Shoaib et al. (2025)
Customer Service and Support	- CRM systems for comprehensive customer data management - AI & Chatbots for 24/7 automatic customer query responses - Automation in Order Handling for automatic order confirmation and shipping cost calculation	Ngai et al. (2021); Spring et al. (2022); Chatterjee & Chaudhuri (2023); Hossain et al. (2024); Ugbebor et al. (2024)
Logistics Communication and Order Processing	- Cloud Computing for real-time data management - Real-time Order Status Tracking for immediate product status updates - Integration with Digital Tools (WMS, TMS, CRM)	Temjanovski et al. (2021); Zou & Jian (2022); Sharma & Panda (2023); Alnaimat et al. (2024); Sornprom (2024)
Purchasing and Procurement	- e-Procurement System for requesting quotes and selecting suppliers online - Supplier Evaluation based on historical data - Real-time Order Monitoring to track order status throughout the process	Zhu et al. (2022); Jain (2023); Gurgun et al. (2024); Raghul et al. (2024); Sarjono et al. (2024)
Materials Handling and Packaging	- Automation including conveyor belts, automated sorting systems - Robotics AGVs for product movement, automatic	Štaffenová et al. (2023); Li (2024); Minashkina (2024); Kumar & Sudarvel (2025)

Logistic Activities	Digital Transformation Application	References
	packing systems - System Integration with WMS for accuracy	

TABLE 1 (EXT.)

Logistic Activities	Digital Transformation Application	References
Facility Site Selection, Warehousing, and Storage	- Automated Storage and Retrieval Systems (AS/RS) - Robotics for sorting and moving goods - Digital Twin to simulate and improve warehouse management - Augmented Reality (AR) for warehouse navigation	Kang (2020); Feng et al. (2023); Attah et al. (2024); Minh (2024); Pour et al. (2025)
Inventory Management	- IoT Sensors for real-time product tracking - Warehouse Management System (WMS) for automatic inbound/outbound control - Predictive Analytics to forecast product demand - Blockchain to verify inventory data accuracy	Samanta & Golui (2023); Bousselmi et al. (2024); Mwakima & Osoro (2024); Pasupuleti et al. (2024); Rani et al. (2024)
Transportation	- Transportation Management System (TMS) for route, load, and cost management - AI-powered Route Optimization for real-time best route calculations - Telematics & GPS Tracking for vehicle location and performance monitoring	Boukerche & Wang (2020); Zohari & Nazri (2021); Ang et al. (2022); Eljazović et al. (2024); Tae-Woo Lee et al. (2024)
Reverse Logistics	- Digital Return Portals for easy online returns - RFID/Barcode Scanning to track returns - AI-based Return Prediction for forecasting return trends - Analytics for Recovery Value to assess the value of repairs or recycling	Guarnieri et al. (2020); Plaza-Úbeda et al. (2020); Starostka-Patyk (2021); Al Doghan & Sundram (2023); Tebaldi et al. (2023)

To present the findings in a coherent and systematic way, the results are summarized as shown in Table 2, which illustrates the linkage between digital technologies, logistics activities, and their impacts on key performance indicators (KPIs). The comparison underscores how different clusters of technologies-such as AI/ML, IoT/RFID, blockchain, cloud computing, big data analytics, robotics and automation, AR/VR, and digital twins-yield distinct performance outcomes when applied across the nine fundamental logistics activities. By mapping each technology to its relevant operational domain, the table offers an integrated perspective that clarifies how digital transformation most effectively enhances efficiency, accuracy, resilience, customer satisfaction, and sustainability within the logistics sector.

TABLE 2 Digital Technologies and KPI Effects Across the Nine Logistics Activities

Logistics Activity	Digital Technologies	KPI Effects
Demand Forecasting and Planning	AI/ML, Big Data/Analytics, Cloud	Forecast accuracy ↑, Service level ↑, Inventory cost ↓
Customer Service and Support	Chatbots/AI NLP, CRM platforms, Mobile apps	Customer satisfaction ↑, Response time ↓, First-contact resolution ↑
Logistics Communications and Order Processing	IoT/RFID, Cloud-based OMS, Blockchain	Order accuracy ↑, Order cycle time ↓, Errors ↓
Purchasing and Procurement	Blockchain, Cloud procurement systems, E-marketplaces	Transparency ↑, Procurement lead time ↓, Supplier reliability ↑
Materials Handling and Packaging	Robotics/Automation, AR/VR, IoT sensors	Safety ↑, Handling time ↓, Packaging waste ↓
Facilities Site Selection, Warehousing, and Storage	Digital Twins, GIS/Big Data Analytics, Smart Warehousing (IoT, WMS, Robotics)	Location efficiency ↑, Storage utilization ↑, Operating cost ↓
Inventory Management	IoT/RFID, Cloud-based IMS, Predictive Analytics	Stock-outs ↓, Inventory turnover ↑, Holding cost ↓

TABLE 2 (EXT.)

Logistics Activity	Digital Technologies	KPI Effects
Transportation	IoT telematics, AI route optimization, Cloud-based TMS, Autonomous vehicles	On-time delivery ↑, Fuel cost ↓, Carbon emissions ↓, Vehicle utilization ↑
Reverse Logistics	Blockchain, IoT tracking, Cloud-based RL systems	Return cycle time ↓, Recycle/Reuse rate ↑, Recovery value ↑, Waste disposal cost ↓

Note. Adapted from synthesized logistics and digital transformation literature (2015–2025)

To situate the evidence, Table 3 sets out a Maturity–Impact Matrix that locates each digital technology by its current industry readiness from emerging to highly mature against its demonstrated effect on logistics performance. The matrix clarifies where "quick wins" are most plausible technologies that are both mature and high-impact and where "strategic bets" are warranted newer or mid-maturity options already delivering medium-to-high gains.
Additionally, by pairing each technology with representative activities and KPIs, it provides a practical lens for prioritizing investments and sequencing scale-ups across the nine logistics activities.

TABLE 3 Maturity–Impact Matrix of Digital Technologies in Logistics

Technology	Maturity Level	Impact on Logistics Performance	Example Logistics Activities	Key KPIs Affected
AI / ML	High	High	Forecasting, Customer Service, Transportation	Forecast accuracy, On-time delivery, Customer satisfaction
IoT / RFID	High	High	Inventory Management, Warehousing, Transportation	Stock-out rate, Order accuracy, Asset utilization
Blockchain	Medium	Medium–High	Procurement, Reverse Logistics, Order Processing	Transparency, Compliance, Traceability
Cloud Computing	High	High	Order Processing, Communication, CRM	Order cycle time, Flexibility, Responsiveness
Big Data / Analytics	High	High	Forecasting, Site Selection, Procurement	Cost reduction, Decision quality, Planning accuracy
Robotics / Automation	Medium–High	High	Warehousing, Materials Handling, Packaging	Handling time, Safety, Error rate
AR / VR	Low–Medium	Medium	Training, Materials Handling, Packaging	Training time, Safety, Error reduction
Digital Twins	Emerging–Medium	Medium–High	Site Selection, Warehousing, Transportation	Cost optimization, Resilience, Utilization

Note. Adapted from synthesized logistics and digital transformation literature (2015–2025)

3.3 Challenges of Digital Transformation in Logistics for Competitive Advantage and Sustainable Growth

Digital transformation in the logistics industry plays a crucial role in gaining a competitive advantage and achieving sustainable growth. However, businesses face numerous challenges when adapting and integrating new technologies into their processes to enhance efficiency and remain competitive in a rapidly changing market. These challenges include:

3.3.1 Challenges of Investment in New Technologies

Investing in expensive digital technologies, such as automation systems, IoT, AI, and blockchain, can be a barrier for many organizations, especially small and medium-sized enterprises (SMEs) with limited budgets. Additionally, businesses need to consider investing in employee training to effectively utilize these new technologies. These challenges may prevent some organizations, particularly SMEs, from accessing or managing these technologies (Faridi & Malik, 2020; Mvubu & Naude, 2024).

3.3.2 Challenges in Developing Personnel Skills

Integrating digital technologies into logistics requires skilled personnel who can not only operate the new technologies but can also adapt quickly to changes within various systems. However, many organizations find it challenging to develop their workforce in this regard, both in terms of training and finding experts in digital technologies. Therefore, it is essential to have a training plan that supports the development of relevant skills, enabling employees to fully utilize new tools and technologies (Foroughi, 2021).

3.3.3 Changes in Work Processes and Organizational Culture

The digitalization in logistics is not merely about implementing new technologies; it also requires changes in work processes and employee mindsets. This may lead to delays in adaptation or resistance from employees accustomed to traditional ways of working. For instance, implementing automation systems or technologies like AI often requires changes to existing workflows, which may cause some employees to feel uncertain or unprepared for the change (Suhu, 2023).

3.3.4 Challenges in Adapting to Changing Market Demands

The logistics market is evolving rapidly, particularly due to the growing impact of e-commerce. Entrepreneurs need to be flexible in adapting to customer demands that change over time. This may involve modifying work processes or management systems to meet the shifting expectations of customers and the challenges presented by the market (Paužuolienė et al., 2024).

3.3.5 Challenges in Managing Complex Supply Chains

The use of digital technologies in supply chain management requires consideration of the complexity of linking data from multiple sources, such as suppliers, shippers, and customers. Managing data and communication across all these sectors requires systems capable of efficiently linking and processing information. Advanced technologies, such as blockchain, may be needed to ensure transparency and accuracy in supply chain operations (Burinskiene & Daskevic, 2024).

Digital transformation in logistics is a challenging process. However, it also presents an opportunity to gain a competitive advantage and promote sustainable growth. If businesses can effectively address these challenges by investing in suitable technologies, developing employee skills, adapting work processes, and ensuring data security, they will be better positioned for a smooth and successful digital transformation in the long term.

IV. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion of the Application of Digital Transformation in Logistics

Digital transformation in the logistics industry plays a crucial role in enhancing the efficiency of all stages of logistics activities, including demand forecasting, customer service, order processing, procurement, materials and warehouse management, inventory control, transportation, and reverse logistics. Key technologies driving these transformations include the Internet of Things (IoT), which is used for monitoring and tracking goods within warehouses and during transit. Big Data Analytics aids in demand forecasting and production planning. Artificial Intelligence (AI) is used to optimize transportation routes and improve customer service efficiency. Blockchain ensures tracking and verification of data within logistics processes. Robotics & Automation enhances speed and accuracy in warehouse management, and Cloud Computing facilitates smooth and efficient coordination between systems in the supply chain.

The application of digital technologies in logistics not only elevates operational efficiency but also reduces costs, errors, and increases transparency and flexibility in responding to customer demands in the rapidly changing digital economy. Therefore, it is a key element in developing and enhancing the capabilities of the logistics industry today. However, the adoption of these technologies still faces several challenges, including high investment costs, a shortage of skilled personnel, data security risks, and difficulties in adapting internal processes, which often require time to understand and align with new systems.

In conclusion, the application of digital technologies across the nine logistics activities enhances operational capabilities and effectively meets customer demands. However, this transformation can only be sustainable if supported by both the business and government sectors, through policies, technology development, and systematic human resource enhancement.

4.2 Recommendations for the Application of Digital Technologies in Logistics Activities

Based on the findings of this study, recommendations for organizations seeking to apply digital technologies in logistics processes to enhance efficiency include:

• Before investing in new technologies, organizations should assess the readiness of their internal digital infrastructure and evaluate the business needs that can benefit from digital technologies. For example, evaluating the needs for warehouse management and transportation can ensure that investments in technology are effective.

• Digital transformation cannot succeed without the skills and knowledge of the organization's personnel. Therefore, employee training should be conducted to ensure they possess the necessary understanding and skills to operate new technologies. Additionally, digital skills should be strengthened across all employee levels.

• In order to choose the right technology, organizations should consider the size of the business and operational characteristics. For example, smaller transportation companies that may not be able to invest in full automation should consider cost-effective technologies such as RFID-based warehouse management systems or GPS-based transportation tracking systems.

• When applying digital technologies, organizations should bear in mind their impact on the environment and society. The selection of technologies that reduce energy consumption and minimize emissions in transportation and warehouse processes should be prioritized.

V. MANAGERIAL AND POLICY IMPLICATIONS

Translating the evidence into action calls for a phased implementation plan alongside system-level enablers that allow solutions to scale at the firm and supply-chain levels.

5.1 Crawl-Walk-Run roadmaps (by activity).

In the near term (Crawl), lay the data groundwork and improve process visibility: instrument frontline operations with IoT/RFID, consolidate data on the cloud, and harmonize master data so information is reliable and ready to use. Over the medium term (Walk), move toward data-driven decisions by applying analytics/AI to core tasks forecasting, slotting/storage assignment, and routing and pilot robotics in high-variance warehouses to quantify KPI gains and operational ROI. At scale (Run), focus on integration: use digital twins for scenario planning and network design, extend blockchain for end-to-end traceability, and formalize a data governance council to oversee standards, shared data, and long-term protection.

5.2 Ease-impact prioritization.

Quick wins include cloud-based WMS/TMS rollouts, upgrading barcode to RFID for inventory counting and tracking, and baseline routing optimization measures that cut cycle time and cost while improving accuracy. Strategic bets target the next performance curve: digital twins for network design and "what-if" analysis, goods-to-person robotics to relieve warehouse bottlenecks, and blockchain to support multi-party ESG reporting. On the policy side, reinforce the ecosystem by promoting interoperability standards (e.g., GS1), creating incentives for credible Scope-3 measurement and data connectivity, and developing sectoral data spaces to enhance transparency and benchmarking.

5.3 Governance and measurement.

To ensure that investments work-and can be scaled-set baseline KPIs in advance (time, cost, accuracy, service level, and sustainability/carbon), define milestones or stage-gates for continue–pause–pivot decisions, and embed data governance, common data standards, and analytics capability as cross-cutting requirements in every project. All actions should align with each firm's TOE context (Technology–Organization–Environment) and map explicitly to the nine logistics activities, so priorities are clear and value creation is demonstrable in both managerial and policy terms.

VI. FUNDING ACKNOWLEDGEMENTS

This article received funding for publication from King Mongkut's Institute of Technology Ladkrabang. The content of this article is part of the doctoral dissertation titled *Digital Transformation Affecting the Competitive Advantage and Sustainable Growth of Logistics Service Providers in Thailand*, submitted for the Doctor of Philosophy degree in Business Administration at King Mongkut's Institute of Technology Ladkrabang. The dissertation has been reviewed and approved according to the standards of the Research Ethics Committee of Rangsit University (Certification Number: RSUERB2025-016).

REFERENCES

➢ Adeniran, A. O., Sidiq, O. B., Oyeniran, G. T., & Adenira, A. A. (2024). Sustainability impact of digital transformation in E-commerce logistics. International journal of innovation in marketing elements, 4(1), 1-18.

➢ Adesoga, T. O., Ajibaye, T. O., Nwafor, K. C., Imam-Lawal, U. T., Ikekwere, E. A., & Ikechukwu, D. (2024). The rise of the" smart" supply chain: How AI and automation are revolutionizing logistics. International Journal of Science and Research Archive, 12(2), 790-798.

➢ Ait Mouha, R. A. R. (2021). Internet of things (IoT). Journal of Data Analysis and Information Processing, 9(02), 77.

➢ Al Doghan, M. A., & Sundram, V. P. K. (2023). AI-enabled reverse logistics and big data for enhanced waste and resource management. Operational Research in Engineering Sciences: Theory and Applications, 6(2).

➢ Al Mashalah, H., Hassini, E., Gunasekaran, A., & Bhatt, D. (2022). The impact of digital transformation on supply chains through e-commerce: Literature review and a conceptual framework. Transportation Research Part E: Logistics and Transportation Review, 165, 102837.

➢ Alnaimat, M. A., Kharit, O., Mykhailenko, I., Palchyk, I., & Purhani, S. (2024). Implementation of cloud computing in the digital accounting system of logistics companies. Acta Logistica, 11(1), 99-109.

➢ Ang, K. L. M., Seng, J. K. P., Ngharamike, E., & Ijemaru, G. K. (2022). Emerging technologies for smart cities' transportation: geo-information, data analytics and machine learning approaches. ISPRS International Journal of Geo-Information, 11(2), 85.

➢ Attah, R. U., Garba, B. M. P., Gil-Ozoudeh, I., & Iwuanyanwu, O. (2024). Strategic frameworks for digital transformation across logistics and energy sectors: Bridging technology with business strategy. Open Access Res J Sci Technol, 12(02), 070-80.

- Attah, R. U., Gil-Ozoudeh, I., Garba, B. M. P., & Iwuanyanwu, O. (2024). Leveraging geographic information systems and data analytics for enhanced public sector decision-making and urban planning. Magna Sci Adv Res Rev, 12(2), 152-63.
- Aubakirova, D. (2024). Directions for using big data analytics in logistics management. Development Management, 1(23), 27-36.
- Behrooz, H., & Hayeri, Y. M. (2022). Machine learning applications in surface transportation systems: A literature review. Applied Sciences, 12(18), 9156.
- Benarbia, T., & Kyamakya, K. (2021). A literature review of drone-based package delivery logistics systems and their implementation feasibility. Sustainability, 14(1), 360.
- Boukerche, A., & Wang, J. (2020). Machine learning-based traffic prediction models for intelligent transportation systems. Computer Networks, 181, 107530.
- Bousselmi, S., Gannouni, M., & Ouni, K. (2024, October). IoT Application for Smart Inventory Management System Based on RFID. In 2024 IEEE International Multi-Conference on Smart Systems & Green Process (IMC-SSGP) (pp. 1-6). IEEE.
- Burinskiene, A., & Daskevic, D. (2024). The investigation on the application of digital technologies for logistics business competitiveness. Tehnički glasnik, 18(4), 626-637.
- Chatterjee, S., & Chaudhuri, R. (2023). Customer relationship management in the digital era of artificial intelligence. In Digital Transformation and Industry 4.0 for Sustainable Supply Chain Performance (pp. 175-190). Cham: Springer International Publishing.
- Chen, W., Men, Y., Fuster, N., Osorio, C., & Juan, A. A. (2024). Artificial intelligence in logistics optimization with sustainable criteria: A review. Sustainability, 16(21), 9145.
- Demir, S., Paksoy, T., & Kochan, C. G. (2020). Logistics 4.0: SCM in Industry 4.0 Era:(Changing Patterns of Logistics in Industry 4.0 and role of digital transformation in SCM). In Logistics 4.0 (pp. 15-26). CRC Press.
- Ding, S., Ward, H., & Tukker, A. (2023). How Internet of Things can influence the sustainability performance of logistics industries–A Chinese case study. Cleaner Logistics and Supply Chain, 6, 100094.
- Eljazović, M., Ezgeta, D., Kamenjašević, N., & Sarajlićć, M. (2024, June). Analysis of Opportunities of Software for Optimization of Transport Routes. In International Conference "New Technologies, Development and Applications" (pp. 165-171). Cham: Springer Nature Switzerland.
- Faridi, M. R., & Malik, A. (2020). Digital transformation in supply chain, challenges and opportunities in SMEs: a case study of Al-Rumman Pharma. Emerald Emerging Markets Case Studies, 10(1), 1-16.
- Fatorachian, H., Kazemi, H., & Pawar, K. (2025). Digital Technologies in Food Supply Chain Waste Management: A Case Study on Sustainable Practices in Smart Cities. Sustainability, 17(5), 1996.
- Feng, Z., Li, G., Wang, W., Zhang, L., Xiang, W., He, X., ... & Wei, N. (2023). Emergency logistics centers site selection by multi-criteria decision-making and GIS. International journal of disaster risk reduction, 96, 103921.
- Ferreira, B., & Reis, J. (2023). A systematic literature review on the application of automation in logistics. *Logistics*, *7*(4), 80.
- Foroughi, A. (2021). Supply chain workforce training: addressing the digital skills gap. Higher Education, Skills and Work-Based Learning, 11(3), 683-696.
- Guarnieri, P., Cerqueira-Streit, J. A., & Batista, L. C. (2020). Reverse logistics and the sectoral agreement of packaging industry in Brazil towards a transition to circular economy. Resources, conservation and recycling, 153, 104541.
- Gurgun, A. P., Kunkcu, H., Koc, K., Arditi, D., & Atabay, S. (2024). Challenges in the integration of e-procurement procedures into construction supply chains. Buildings, 14(3), 605.
- Hongsakul, B., & Chuaychoo, I. (2024). The Influence of Logistics Activity on Sustainable Performance of Air Cargo Business in Thailand. ABAC Journal, 44(4), 176-196.
- Hossain, Q., Hossain, A., Nizum, M. Z., & Naser, S. B. (2024). Influence of artificial intelligence on customer relationship management (crm). International Journal of Communication Networks and Information Security, 16(3), 653-663.
- Immadisetty, A. (2025). Real-Time Inventory Management: Reducing Stockouts and Overstocks in Retail. Journal of Recent Trends in Computer Science and Engineering (JRTCSE), 13(1), 77-88.
- Jain, P., Priyadarshini, J., & Gupta, A. K. (2023). Frameworks, linkages, benefits, challenges, and future scope in procurement 4.0: a systematic literature review from 2014 to 2023. IEEE Transactions on Engineering Management, 71, 10295-10313.
- Jaramillo-Alcazar, A., Govea, J., & Villegas-Ch, W. (2023). Anomaly detection in a smart industrial machinery plant using iot and machine learning. Sensors, 23(19), 8286.
- Jumahat, S., Sidhu, M. S., & Shah, S. M. (2023). A review on the positive implications of augmented reality pick-by-vision in warehouse management systems. Acta logistica, 10(1), 1-10.

- Kang, S. (2020). Warehouse location choice: A case study in Los Angeles, CA. Journal of Transport Geography, 88, 102297.
- Kanimozhi Suguna, S., & Nanda Kumar, S. (2019). Application of cloud computing and internet of things to improve supply chain processes. Edge computing: From hype to reality, 145-170.
- Khan, A. A., Laghari, A. A., Li, P., Dootio, M. A., & Karim, S. (2023). The collaborative role of blockchain, artificial intelligence, and industrial internet of things in digitalization of small and medium-size enterprises. Scientific Reports, 13(1), 1656.
- Khan, S., Tailor, R. K., Uygun, H., & Gujrati, R. (2022). Application of robotic process automation (RPA) for supply chain management, smart transportation and logistics. International Journal of Health Sciences, 6(S3), 11051-11063.
- Kumar, M. K., & Sudarvel, J. (2025). Problems on material handling, storage, and packaging in selected logistic companies in Coimbatore. In Recent Research in Management, Accounting and Economics (RRMAE) (pp. 545-548). Routledge.
- Lagorio, A., Di Pasquale, V., Cimini, C., Miranda, S., & Pinto, R. (2022). Augmented Reality in Logistics 4.0: implications for the human work. IFAC-PapersOnLine, 55(10), 329-334.
- Li, P. (2024). Machinery and logistics: Development trends and prospects of automated warehouse technology. Applied and Computational Engineering, 65, 81-88.
- Logistics Office, Department of Primary Industries and Mines, Ministry of Industry of Thailand. (2015). Fundamentals of Logistics and Supply Chain Management. Bangkok: Aprin & Pack Co., Ltd.
- Manastrong, N., Yaemyongwan, P., Boonsong, K., & Klinngam, S. (2023). Transformation of Educational Organizations into the Digital Disruption Era. *Journal of MCU Ubon Review, 8*(2). 99-108.
- Minashkina, D. (2024). A review and research agenda for recent socially and environmentally sustainable practices for warehouse management systems. The International Journal of Logistics Management, 35(7), 60-98.
- Minh, V. (2024). Technology in Warehouse Management. Transforming Logistics in a Developing Nation: Vietnam's Technology Imperative, 297.
- Mvubu, M., & Naude, M. J. (2024). Digital transformation at third-party logistics providers: Challenges and best practices. Journal of Transport and Supply Chain Management, 18, 1023.
- Mwakima, F. M., & Osoro, A. (2024). Inventory management practices and performance of logistic firms in nairobi city county, kenya. International Journal of Social Sciences Management and Entrepreneurship (IJSSME), 8(3).
- Ngai, E. W., Lee, M. C., Luo, M., Chan, P. S., & Liang, T. (2021). An intelligent knowledge-based chatbot for customer service. Electronic Commerce Research and Applications, 50, 101098.
- Nguyen, H. P. (2020). Sustainable development of logistics in Vietnam in the period 2020–2025. International Journal of Innovation, Creativity and Change, 11(3).
- Nurgaliev, I., Eskander, Y., & Lis, K. (2023). The use of drones and autonomous vehicles in logistics and delivery. Logistics and Transport, 57.
- Nugroho, G., Tedjakusuma, F., Lo, D., Romulo, A., Pamungkas, D. H., & Kinardi, S. A. (2023). Review of the application of digital transformation in food industry. Journal of Current Science and Technology, 13(3), 774-790.
- Ogunkan, D. V., & Ogunkan, S. K. (2025). Exploring Big Data Applications in Sustainable Urban Infrastructure: A Review. Urban Governance.
- Ozkan-Ozen, Y. D., Akcicek, C., & Ozturkoglu, Y. (2025). Machine learning applications in smart logistics: analysing barriers for future practices. Journal of Engineering, Design and Technology.
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71
- Paramesha, M., Rane, N. L., & Rane, J. (2024). Big data analytics, artificial intelligence, machine learning, internet of things, and blockchain for enhanced business intelligence. Partners Universal Multidisciplinary Research Journal, 1(2), 110-133.
- Pasupuleti, V., Thuraka, B., Kodete, C. S., & Malisetty, S. (2024). Enhancing supply chain agility and sustainability through machine learning: Optimization techniques for logistics and inventory management. Logistics, 8(3), 73.
- Paužuolienė, J., Kaveckė, I., & Pyra, M. (2024). Smart Technologies Integration and Challenges in the Context of Logistics Companies. European Research Studies Journal, 27(4), 2081-2100.
- Perevozova, I., Gubernat, T., Hontar, L., Shayban, V., & Bocharova, N. (2024). Using Big Data Analytics to Improve Logistics Processes and Forecast Demand. Pacific Business Review International, 17(4).

- Plaza-Úbeda, J. A., Abad-Segura, E., de Burgos-Jiménez, J., Boteva-Asenova, A., & Belmonte-Ureña, L. J. (2020). Trends and new challenges in the green supply chain: The reverse logistics. Sustainability, 13(1), 331.
- Plazibat, I., Marunica, S., & Gagić, M. (2024). Warehouse management system (WMS) in retail logistics. In 2024 Contemporary issues in economy & technology (CIET) conference proceedings (pp. 549-560).
- Pour, M., Dogot, T., Lebailly, P., Lopez-Carr, D., & Azadi, H. (2025). Determinants of site selection for the warehouses of food logistic providers. Environment, Development and Sustainability, 1-15.
- Radivojević, G., & Milosavljević, L. (2019, May). The concept of logistics 4.0. In 4th Logistics international conference (pp. 23-25).
- Raghul, S., Jeyakumar, G., Anbuudayasankar, S. P., & Lee, T. R. (2024). E-procurement optimization in supply chain: A dynamic approach using evolutionary algorithms. Expert Systems with Applications, 255, 124823.
- Raja, G. B. (2021). Impact of internet of things, artificial intelligence, and blockchain technology in Industry 4.0. Internet of Things, Artificial Intelligence and Blockchain Technology, 157-178.
- Ramya, J., Yerraguravagari, S. S., Gaikwad, S., & Gupta, R. K. (2024). AI and Machine Learning in Predictive Analytics: Revolutionizing Business Strategies through Big Data Insights. Library of Progress-Library Science, Information Technology & Computer, 44(3).
- Rani, N., Sharma, M. K., Kathuria, S., Yamsani, N., Akram, S. V., & Balyan, R. (2024, March). Revolutionizing inventory management: The role of IoT in inventory management 4.0. In 2024 3rd International Conference on Sentiment Analysis and Deep Learning (ICSADL) (pp. 642-646). IEEE.
- Ravi Chandra, B., Kumar, K., Roy, A., & Chandra, I. S. (2024). Overview of Internet of Things-Based Smart Logistics Systems. Communication Technologies and Security Challenges in IoT: Present and Future, 241-259.
- Remondino, M. (2020). Augmented reality in logistics: qualitative analysis for a managerial perspective. International journal of logistics systems and management, 36(1), 1-15.
- Rofi'i, Y. U. (2023). Analysis of E-Commerce Purchase Patterns Using Big Data: An Integrative Approach to Understanding Consumer Behavior. International Journal Software Engineering and Computer Science (IJSECS), 3(3), 352-364.
- Samanta, H., & Golui, K. (2023). Smart Inventory Control: Proposed Framework on Basis of IoT, RFID, and Supply Chain Management. Intelligent Manufacturing Management Systems: Operational Applications of Evolutionary Digital Technologies in Mechanical and Industrial Engineering, 113-139.
- Sarjono, H., Hartawan, F. A., & Silviya, I. (2024, July). E-Supply Chain, E-Procurement, ERP's Impact on Indonesia's Industry Performance. In Proceedings of the 2024 15th International Conference on E-business, Management and Economics (pp. 106-110).
- Sharma, P., & Panda, S. (2023). Cloud computing for supply chain management and warehouse automation: a case study of azure cloud. International journal of smart sensor and adhoc network, 3(4), 19-29.
- Shoaib, M., Zhang, S., Ali, H., Ahmad, M. S., & Khan, M. A. (2025). Integrating circular economy while adopting digital twin for enhancing logistics efficiency: a hybrid Fuzzy Delphi-FUCOM based approach. International Journal of Logistics Research and Applications, 1-43.
- Simon, J. (2024). Augmented Reality Based Industrial Digitalization and Logistics. Analecta Technica Szegedinensia, 18(4), 1-8.
- Sodiya, E. O., Umoga, U. J., Amoo, O. O., & Atadoga, A. (2024). AI-driven warehouse automation: A comprehensive review of systems. GSC Advanced Research and Reviews, 18(2), 272-282.
- Sornprom, N. (2024). Role of Cloud Computing & Artificial Intelligence in the Logistics & Supply Chain Industry. weather, 12(6).
- Spring, M., Faulconbridge, J., & Sarwar, A. (2022). How information technology automates and augments processes: Insights from Artificial-Intelligence-based systems in professional service operations. Journal of Operations Management, 68(6-7), 592-618.
- Štaffenová, K., Rakyta, M., & Biňasová, V. (2023). The use of automated guided vehicles in the internal logistics of the production company. Transportation Research Procedia, 74, 458-464.
- Starostka-Patyk, M. (2021). The use of information systems to support the management of reverse logistics processes. Procedia Computer Science, 192, 2586-2595.
- Sahu, A. (2023). Navigating Change: Exploring the Impact of Digital Transformation on Organizational Culture. TECHNO REVIEW Journal of Technology and Management, 3(4), 01-05.
- Tae-Woo Lee, P., Chhetri, P., Liu, W., & Lin, C. W. (2024). Integrated transport and logistics for sustainable global trade. International Journal of Logistics Research and Applications, 27(3), 359-362.
- Tebaldi, L., Reverberi, D., Romagnoli, G., Bottani, E., & Rizzi, A. (2023). RFID technology in Retail 4.0: state-of-the-art in the Fast-Moving Consumer Goods field. International Journal of RF Technologies, 13(2), 105-133.

- Temjanovski, R., Bezovski, Z., & Apasieva, T. J. (2021). Cloud computing in logistic and Supply Chain Management environment. Journal of Economics (1857-9973), 6(1).
- Ten Hompel, M., Rehof, J., & Wolf, O. (Eds.). (2015). Cloud computing for logistics. Springer International Publishing.
- Tran-Dang, H., Krommenacker, N., Charpentier, P., & Kim, D. S. (2022). The Internet of Things for logistics: Perspectives, application review, and challenges. IETE Technical Review, 39(1), 93-121.
- Ugbebor, F., Adeteye, M., & Ugbebor, J. (2024). Automated Inventory Management Systems with IoT Integration to Optimize Stock Levels and Reduce Carrying Costs for SMEs: A Comprehensive Review. Journal of Artificial Intelligence General Science (JAIGS) ISSN: 3006-4023, 6(1), 306-340.
- Velmurugan, K., Saravanasankar, S., Venkumar, P., & Pandian, R. S. (2022, September). Digital transformation in the context of maintenance management systems in SMEs: critical factors and empirical effects.Journal of Current Science andTechnology, 12(3), 428-438. DOI:10.14456/jcst.2022.33
- Verma, P. (2024). Transforming Supply Chains Through AI: Demand Forecasting, Inventory Management, and Dynamic Optimization. Integrated Journal of Science and Technology, 1(9).
- Woschank, M., Rauch, E., & Zsifkovits, H. (2020). A review of further directions for artificial intelligence, machine learning, and deep learning in smart logistics. Sustainability, 12(9), 3760.
- Zhu, Q., Liu, A., Li, Z., Yang, Y., & Miao, J. (2022). Sustainable supplier selection and evaluation for the effective supply chain management system. Systems, 10(5), 166.
- Zohari, M. H., & Nazri, M. F. B. M. (2021). GPS based vehicle tracking system. International Journal of Scientific & Technology Research, 10(04), 278-282.
- Zohdi, M., Rafiee, M., Kayvanfar, V., & Salamiraad, A. (2022). Demand forecasting based machine learning algorithms on customer information: an applied approach. International Journal of Information Technology, 14(4), 1937-1947.
- Zou, J., & Jian, C. (2022). Does cloud computing improve team performance and employees' creativity?. Kybernetes, 51(2), 582-601.