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ARTIFICIAL INTELLIGENCE AND OPTIMIZATION OF REVERSE LOGISTICS: AN ANALYSIS IN THE AQUATIC INDUSTRY OF THE MEKONG DELTA

Tran Trung Chuyen[1]*, Phan Tran Xuan Trinh[2], Tran Thanh Huy[23], Nguyen Tri Khiem[4], Nguyen Van Tac[5]
Facuty of Business Administration - Marketing, Nam Can Tho University, Can Tho, Vietnam[14]
Faculty of Technology and Engineering, Nam Can Tho University, Can Tho, Vietnam[23]
Faculty of Economics, Nam Can Tho University, Can Tho, Vietnam[5]
ttchuyen@nctu.edu.vn[1*], ptxtrinh@nctu.edu.vn[2], tranthanhhuy@nctu.edu.vn[3], nkkhiem@nctu.edu.vn[4], nvtac@nctu.edu.vn[5]

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**Corresponding Author*

ABSTRACT
In recent years, artificial intelligence (AI) has become an important technology that enhances the competitive advantages for businesses. This study investigates the application of artificial intelligence and how it can optimize reverse logistics for the aquatic industry in the Mekong Delta. It also explores the current situation in applying AI, its benefits, and challenges when using AI in reverse logistics for aquatic enterprises. The research uses qualitative and quantitative methods to collect data from interviewing managers, logistics staff, and technicians to deliver a survey to 41 seafood businesses. Results show AI applications in forecasting, storage, and recycling can cut operational costs by over 10% for 46.3% of firms and improve recovery time by over 10% for 56.1%. Benefits also include higher operational efficiency and better environmental performance. However, challenges persist in system integration, data access, and workforce readiness. The study provides practical recommendations, including enhancing AI workforce training, system integration, and collaboration with technology providers, to help seafood companies overcome barriers and maximize the benefits of AI in reverse logistics.
Keywords: *Aquatic Industry, Artificial Intelligence, Reverse Logistics, Seafood Supply Chain.*

1. Introduction

Artificial Intelligence (AI) has become one of the most important technologies worldwide over the last decade. This technology is believed to be a key factor in the development of global social economies (Krstić et al., 2022). The application of AI will optimize the operating systems to minimize human involvement. Lei & Hui (2024) discussed the transformative impact of AI on the logistics industry, with a particular focus on the development of transportation and distribution hubs, and the integration of AI into inventory management and logistics distribution solutions. Moreover, the findings of Vasiliki & Apostolos, (2023) emphasized the integration of AI with robotics and blockchain technology, which enhances operational efficiency, transparency, traceability, and security in logistics. AI technology allows computers and machines to imitate human learning, problem-solving, decision-making, creativity, and autonomy (Wamba-Taguimdje et al., 2020). On the other hand, by utilizing algorithms, machine learning, and deep learning, AI also provides an optimal solution for developing and controlling the reverse logistics system (Liu, 2024). Reverse logistics is the technique of managing and collecting returned products. Unlike forward logistics, this process is more complex because it requires collaboration among all parties (Simons et al., 2024).

The Mekong Delta is a key region in Vietnam for producing and harvesting agricultural products. Statistics show that it accounts for about 90% of Vietnam's rice exports, 70% of its fruit, and 60% of its seafood (Le, 2025). However, seafood production in this area faces challenges like climate change, resource limitations, and the need for sustainable development, which can threaten output levels (Quang et al., 2023). Consequently, for industries such as aquaculture and seafood, implementing an effective reverse logistics system is crucial not only for economic success but also for environmental sustainability, especially given the increasing pressures of climate change and resource scarcity (Beijnen & Yan, 2024). Reverse logistics involves reclaiming value from end-of-life products through reuse, recycling, refurbishment, repair, and remanufacturing. This process plays a vital role in recycling efforts, delivering economic, environmental, and social benefits (Fani et al., 2025). When integrated with AI technologies, such as predictive analytics, optimization algorithms, and real-time monitoring, reverse logistics offers substantial opportunities to improve resource use, minimize waste, and promote circular economy practices (Grover et al., 2020).

Despite the potential for AI in reverse logistics, most current research focuses on logistics broadly or across industries, with limited attention to specific sectors or regions (Krstić et al., 2022; Liu, 2024). Recent studies highlight AI's role in transportation, warehousing, and distribution; however, little is known about its application to reverse logistics in resource-heavy sectors like the aquatic industry (Yetunde Adeoye et al., 2025; Rad et al., 2025; Perotti et al., 2024). This is a vital gap, as the aquatic sector faces unique challenges, including infrastructural constraints, sustainability concerns, and rising production needs, which influence the deployment and success of AI solutions (Tran et al., 2025). The Mekong Delta, a major hub for Vietnam's seafood exports, illustrates this challenge: while crucial for the seafood industry, it is also highly susceptible to environmental threats, resource inefficiencies, and global market shifts (Le, 2025; Quang et al., 2023). Research on how AI can support reverse logistics in this region's seafood enterprises is scarce.

This study aims to explore how AI can facilitate and implement reverse logistics, especially for seafood businesses in the Mekong Delta. It will also assess the benefits and drawbacks of AI adoption, contributing to both theoretical insights and practical outcomes in reverse logistics for the seafood sector. By using qualitative and quantitative methods, this study will collect data from experts and seafood enterprises to analyze and provide recommendations to help businesses overcome the obstacles. The findings are valuable for all stakeholders in the supply chain sector because their recommendations can enhance the reverse logistics process. The study's objectives include assessing the current state and challenges of reverse logistics in the Mekong Delta's aquatic industry, analyzing how AI can improve efficiency, sustainability, and circularity, and offering managerial and policy guidance for leveraging AI in emerging economies. In doing so, the research advances both theory and practice, enriching academic understanding by linking AI and reverse logistics in an understudied region and providing practical advice to enhance competitiveness and sustainability in seafood supply chains.

The following sections of this paper are structured as follows: Section 2 covers the theoretical framework on reverse logistics and its applications. Section 3 presents the current state of the fisheries sector in the Mekong Delta and the challenges of applying AI in reverse logistics. Section 4 outlines the research methodology employed in the study. Section 5 details the findings from the experimental survey. Finally, Section 6 includes the conclusions and discussions related to the topic.

2. Literature review

2.1. The definition of reverse logistics

Reverse logistics is the return of used products to be reused for many other purposes. It shows that reverse logistics is the opposite side of the regular activities of the supply chain process. The definition of this term is quite different among the studies depending on the authors' perspective. Some researchers mentioned that reverse logistics is the management process of recovery products to eliminate waste and enhance value for businesses (Prajapati et al., 2019). Besides that, other studies considered reverse logistics as waste management to dispose of products and packages (Safdar et al., 2020; Salas-Navarro et al., 2024).

However, the definition of reverse logistics has been developed widely from time to time involving many different aspects. It includes the activities of planning, applying, and controlling the effective flow of raw materials, work-in-process inventory, and finished goods from the consumption point to the origin point for reusing or recycling used products (Simons et al., 2024). In addition, reverse logistics can help retrieve unsold and defective goods to repair, remanufacture, and recycle products (Gautam & Bolia, 2024; Salas-Navarro et al., 2024). Based on these studies, the author proposes a reverse logistics process in Figure 1.

The benefits of reverse logistics attract the attention of both businesses and researchers due to its positive effect on the environment and economy (Dabees et al., 2024). Many firms have realized that implementing reverse logistics will bring more benefits in terms of generating higher revenue and profit while minimizing costs (Khan et al., 2024). During the flow of reverse logistics, there are some related costs such as transportation, storage, and repair. In case firms can control and manage their backward flow well, the cost will be reduced (Butt et al., 2023). On the other hand, Dabees et al. (2024) mentioned that the implementation of reverse logistics has a positive impact on the environment because it eliminates non-toxic solid waste and reduces raw materials used. Furthermore, the adoption of reverse logistics will improve customer satisfaction. It can be said that if a firm can build a process to recover defective products quickly, it will satisfy customers better (Pushpamali et al., 2019). And, reverse logistics can also help maintain sustainability and competitive advantages for businesses in the market. However, Naseem et al. (2023) highlighted some barriers to implementing reverse logistics such as coordination issues, a lack of storage systems for returned products, and customer beliefs about the importance of reverse logistics. Also, Pimentel et al. (2022) stressed other barriers such as financial, regulatory, and management issues which can impact directly the operation of reverse logistics.

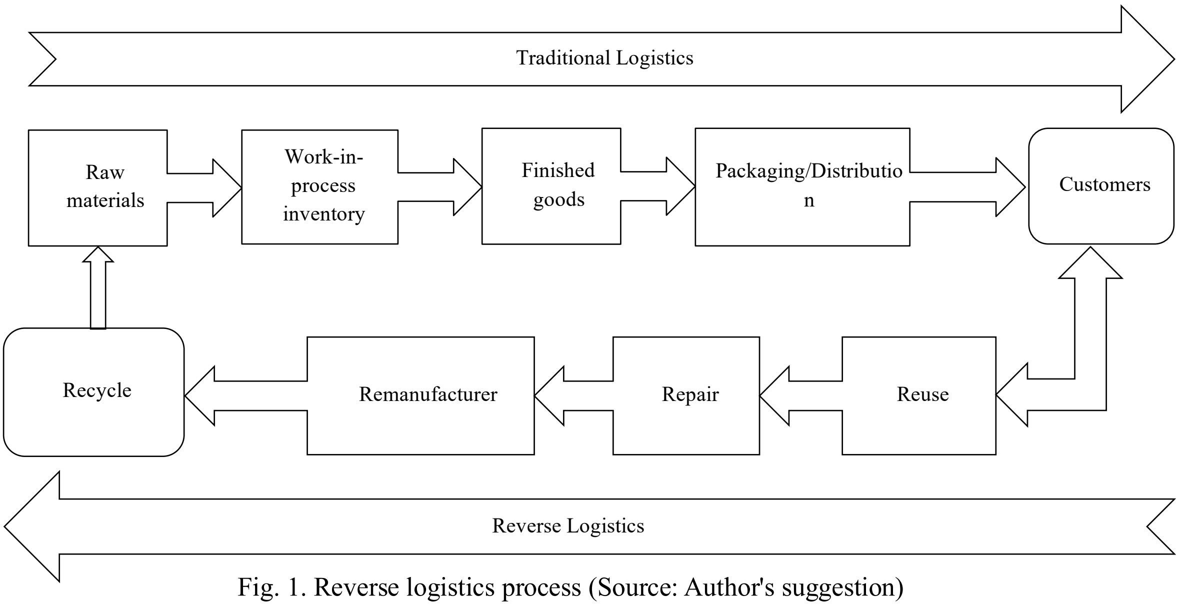

Fig. 1. Reverse logistics process (Source: Author's suggestion)

Overall, reverse logistics offers benefits such as cost reduction, increased profits, and environmental protection. However, the literature highlights ongoing challenges, including poor coordination among supply chain participants and issues related to finances, regulations, and infrastructure. Recent research stresses that successfully implementing reverse logistics requires incorporating advanced technologies like Artificial Intelligence to enhance traceability, process management, and decision-making (Mbago et al., 2025; Gautam & Bolia, 2024; Salas-Navarro et al., 2024).

2.2. Artificial intelligence and its application in supply chain management

Recently, artificial intelligence has become increasingly ubiquitous in both business and research fields. AI is learning, understanding, and practicing activities or knowledge (Cannas et al., 2024; Culot et al., 2024). Artificial means things that humans create (Mikalef & Gupta, 2021). Therefore, artificial intelligence is the concept that people invent an intelligent system that conducts tasks for them (Woschank et al., 2020). Wamba-Taguimdje et al. (2020) defined artificial intelligence as a computer system that has an intelligent algorithm to analyze data and avoid human intervention. Dubey et al. (2020) mentioned AI as a system that can conduct statistical activities, self-learning, and predictive machine-learning techniques to mimic human intelligence. Other researchers considered AI as an ecosystem of technologies that can understand, interpret, learn, plan, and analyze data similar to humans' cognition. It also reproduces humans' actions and minds in learning and processing information. Therefore, implementing AI can help perform difficult tasks and time-consuming activities bringing more benefits for humans and businesses (Grover et al., 2020).

According to Grover et al (2020), AI is considered an analytics tool to enhance supply chain performance. Supply chain operations always need accurate prediction to avoid uncertain demand and bullwhip effect. By using algorithms, AI helps improve information sharing and system integration between parties, increasing demand forecasting accuracy (Balan et al., 2025). Besides that, some AI technologies as machine learning algorithms and deep learning algorithms can optimize inventory management. These advanced techniques predict the level of back orders, estimate the amount of safety stocks, and calculate the number of optimal orders to achieve expected profits (Shen et al., 2024). Also, deep learning and a fuzzy algorithm can analyze the financial risks in the supply chain so that business can control their capital effectively (Hu, 2020). Other researchers reviewed that AI can classify the attributes of products in terms of size, weight, and color through images. It uses a biometric identification tool to recognize the differences between items. Another application of AI in the supply chain process is the traceability of products. AI can track, trace, and identify raw materials or finished goods to ensure quality during distribution. In general, adopting AI can impact all aspects of supply chain management from forecasting, manufacturing, and distribution of products (Patalas-Maliszewska et al., 2024; Pap et al., 2024).

2.3. The benefits of applying artificial intelligence in reverse logistics

Previous uses of AI in reverse logistics highlight its strong potential to optimize recovery, recycling, and remanufacturing. Different AI algorithms have been applied to improve decision-making, forecasting, and efficiency. Convolutional Neural Networks (CNNs) and Deep Neural Networks (DNNs) are commonly used for image and pattern recognition, helping to identify recyclable materials and improve the accuracy of product recovery (Irhuma et al., 2025). Artificial Neural Networks (ANNs) and Random Forests support tasks like demand forecasting, predictive maintenance, and predicting returns (Wilson et al., 2021). Metaheuristic methods, including Genetic Algorithms (GAs), Particle Swarm Optimization (PSO), and Simulated Annealing (SA), aid in solving complex optimization problems in various fields, such as vehicle routing, network design, and resource allocation (Bukhari et al., 2025; Chang et al., 2021). Together, these AI tools support a more sustainable, cost-effective, and data-driven way to manage reverse logistics networks.

From these applications, artificial intelligence can bring benefits to reverse logistics networks in collecting, recycling, remanufacturing, and redelivery (Lickert et al., 2021). When applying technologies, it helps enhance accuracy, safety, and timeliness of all aspects. Firstly, AI can improve the ability to forecast reverse logistics activities by synthesizing historical data and real-time tracking (Liu, 2024). In addition, genetic algorithms can enhance the accuracy of reproducing products because it can recognize the defect based on the vision system. Moreover, AI can have a positive impact on customer satisfaction because it creates a chatbot to interact with customers. From this point, the image processing algorithms can analyze and predict the ability of customers to return the products allowing companies to prepare solutions for collecting and solving returned products (Krstić et al., 2022). According to Tang et al. (2024), AI will contribute to controlling the flow of waste management effectively. It uses deep learning to distinguish waste for recycling or remanufacturing respectively. On the other hand, the application of AI as cobots will avoid the participation of humans in repetitive work and exposure to hazardous materials in the recycling process (Sorell, 2022). AI also helps optimize transport routes in redistributing returned products and reducing business costs (Liu, 2024).

2.4. Current situation of reverse logistics in the seafood industry in the Mekong delta

2.4.1. The seafood supply chain

According to the statistics of the Vietnam Association of Seafood Exporters and Producers, the aquaculture output of the country increased from 4.1 million tons in 2018 to 5.4 million tons in 2023. Among that, the aquaculture for exports is delivered mainly from the Mekong Delta which accounts for 95% of total pangasius production and 80% of shrimp production (Vietnam Association of Seafood Exporters and Producers, 2024).

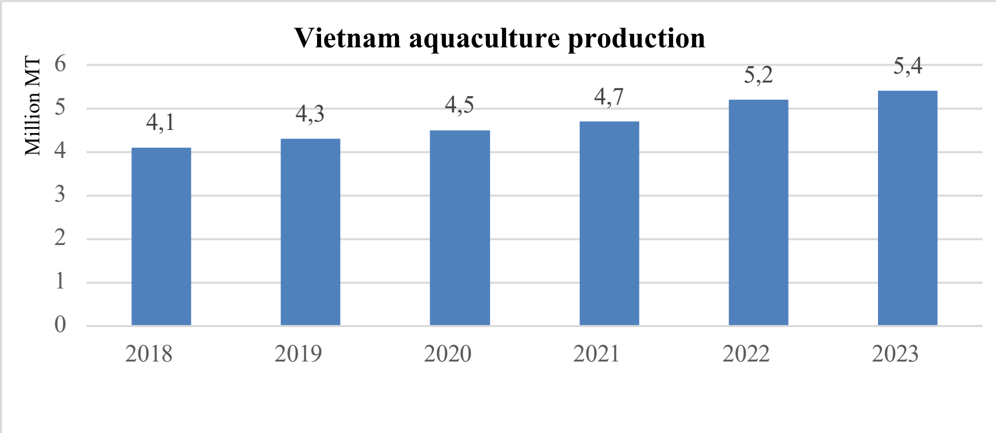

Fig. 2. Vietnam aquaculture production
Source: Vietnam Association of Seafood Exporters and Producers

The statistics also mentioned that Vietnam's fishing output rose from 3.59 million tons to 3.86 million tons between 2018 and 2022. In 2023, the output increased to reach 3.9 million tons and some big fishing provinces are located in the central and south of Vietnam (Vietnam Association of Seafood Exporters and Producers, 2024).

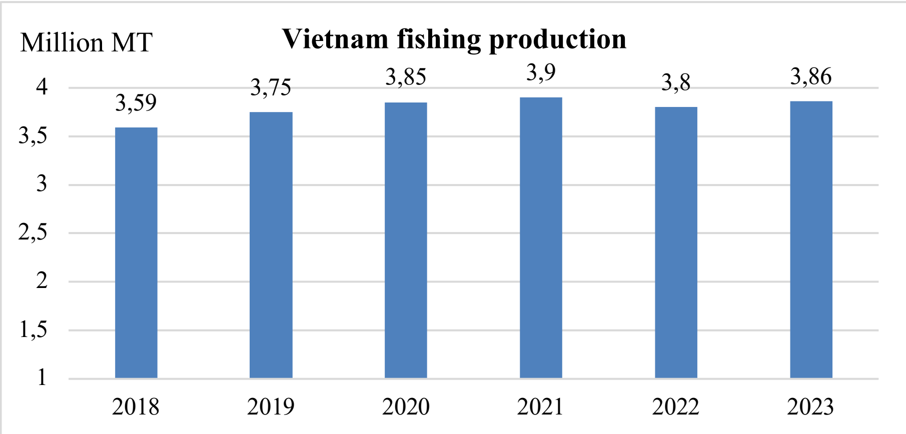

Fig. 3. Vietnam fishing production
Source: Vietnam Association of Seafood Exporters and Producers

In the Mekong Delta, the seafood supply chain connects many channels from farmers to customers (Linh, 2023). Synthesizing from studies by authors such as Hopkins et al. (2024); De et al. (2024); Advani et al. (2024); Iue et al., (2022), and experimental surveys, the author proposes a seafood supply chain model in Figure 3. It shows that in the beginning, farmers will raise or fish aquatic products. After that, the agents will purchase seafood from farmers and they usually have two ways to deliver it. Firstly, they can sell raw products directly to wholesalers and then, these aquatic products will be transported to retailers before selling to customers. Besides that, the agents might provide seafood to manufacturing companies for the processing stage. Then, the processed seafood will be exported to foreign countries such as America, China, Korea, and Australia. In general, each channel is a factor that can link the seafood chain, which contributes to creating value for seafood products. However, the profit distribution among these channels is different, with the agents having the largest share of the profits. They are the intermediate parties who can benefit from farmers, wholesalers, and manufacturers.

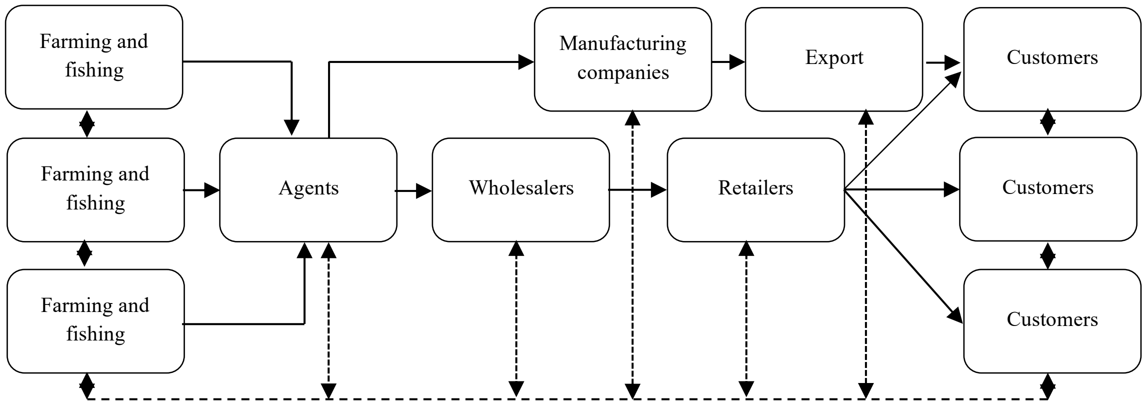

Fig. 4. The seafood supply chain (Source: Author's suggestion)

The seafood industry in the Mekong Delta faces several challenges that affect both its efficiency and sustainability. Most production comes from small-scale farmers, which leads to uneven product quality and makes it hard to track products. Environmental issues, such as water pollution, disease, and climate change, also impact productivity (Rogozhina, 2022; Duy et al., 2021). Problems such as saltwater intrusion and changing water levels add to the risks (Tran & Tortajada, 2022). The lack of reliable cold storage and the limited use of technology lead to increased spoilage after harvest. Rising costs for supplies and transportation make it harder for producers to earn a profit. The sector also needs better infrastructure. Inconsistent regulations and weak enforcement of sustainability standards make it difficult to meet international certification requirements (Huy et al., 2022; Tran et al., 2021; Fry et al., 2024; Tran et al., 2022). All these factors make the industry less competitive and less profitable. To improve, the sector should focus on utilizing digital tools, AI monitoring, and leveraging data to inform decisions.

2.4.2. Challenges in reverse logistics

Despite all the benefits reverse logistics could bring to companies, there are some challenges that businesses have to cope with. The first barriers come from planning and collaboration between parties. A successful reverse logistics system requires cooperation from customers to businesses and some third-party logistics services to run the process smoothly. In case firms can not connect well with customers or third-party logistics, it might lead to poor workflow and increase costs (Mallick et al., 2023). Secondly, reverse logistics impacts the cost structure of business because it includes collection and transportation costs. The firms need to control the process effectively to eliminate waste in the transportation and collection stages (Yu & Sun, 2024). Besides that, the reverse logistics field still lacks skilled labors to manage and plan for the return process. Currently, employees working in this industry lack knowledge and experience or they do not understand the meaning of reverse logistics and its benefits. Another barrier is the lack of information transmission between businesses and customers leading to misunderstandings in the timing, collecting, transporting, and recycling of returned products (Sumrit & Keeratibhubordee, 2024; U-Dominic et al., 2021). Moreover, the challenges are also related to company policies, lack of infrastructure, insufficient collecting process, and management inattention which might impact negatively the return process (Plaza-Úbeda et al., 2020).

2.4.3. Evaluation of Artificial Intelligence Application

Artificial intelligence applications could benefit reverse logistics because of their ability to optimize the process and eliminate barriers. Based on the analysis capabilities, AI can predict the future needs of reverse logistics and provide recommendations for firms to improve the return process (Krstić et al., 2022). Moreover, implementing AI in reverse logistics could enhance the companies' competitive advantages (Bhattacharya et al., 2024). However, advanced technology applications also raise some concerns for businesses and researchers. Among those, cybersecurity and data privacy are the most serious issues that should be considered before applying AI (Upreti et al., 2024). In addition, investment costs are quite high, especially for small and medium enterprises when implementing AI (Peretz-Andersson et al., 2024). Also, unexpected events such as bad weather, traffic congestion, and changes in customers' minds lead to poor AI prediction (Krstić et al., 2022; Liu, 2024). Finally, changing the internal working system to apply AI might cause incompatible issues and in case employees do not have enough skills and knowledge, the return process can not run smoothly (Liu, 2024).

3. Research methods

The design was mixed in terms of methodology, with the qualitative and quantitative methods being used to complement each other (sequentially) so that both exploratory insight and empirical generalization are secured. This integration of methods facilitated a holistic perception of AI in reverse logistics use for Mekong Delta's aquatic industries. Qualitative results informed the development and refinement of the quantitative instrument, which were then triangulated to lend support for valid and robust conclusions.

During the qualitative phase, purposeful sampling was used to select two experts with more than 10 years of logistics and aquaculture management experiences. These experts shared detailed views of the environmental context that comprises reverse logistics and described where things stand with AI implementation for seafood. They were invaluable in the development of a survey instrument that was culturally relevant and comprehensive. Face-to-face expert interviews were transcribed and coded with a thematic analysis in order to identify patterns, which served the later design of the quantitative questionnaire. A pilot survey was then carried out with 16 aquatic enterprises in the Mekong Delta provinces. Subsequently, the author refined and finalized the questionnaire for the official survey.

A systematic survey was given to 45 seafood businesses in the Mekong Delta as part of the quantitative phase. The study used a convenience sample approach because of accessibility issues and the small number of companies using AI in reverse logistics at the moment. Following a thorough and consistent review of the returned questionnaires, 41 valid answers were kept for further examination. The sample included a range of organizational levels with 24 managers (58.5%), 12 logistics employees (29.3%), and 5 technical employees (12.2%).

The questionnaire was developed based on a synthesis of academic literature combined with themes derived from interviews. It consists of four sections. The first section records the level of AI adoption in reverse logistics across four domains: demand forecasting for returns, optimization of storage and transportation, classification and processing of recycling, and management of data and information. Each domain includes binary yes or no questions together with a Likert scale from 1 to 5 to measure the degree of implementation. The second section assesses perceived effectiveness across five key dimensions, including operating cost, recovery time, environmental impact, supply chain transparency, and forecasting capability. Each dimension contains three to four observed variables rated on a Likert scale from 1 to 5, ranging from "strongly disagree" to "strongly agree." The third section evaluates challenges in three groups: technical, cultural and organizational, and managerial, legal, and ethical, using a five-point scale to measure the level of influence. The fourth section presents control variables such as company size, business segment, geographic location, job position, work experience, and the number of years involved in reverse logistics and AI implementation.

The data were analyzed using descriptive statistical methods. Two software programs were employed: Microsoft Excel and IBM SPSS Statistics 20.0. Microsoft Excel was used for data aggregation, variable coding, frequency and percentage calculation, as well as for generating bar and pie charts. IBM SPSS Statistics 20.0 was applied to produce frequency tables, percentages, valid percentages, cumulative percentages, and to compute mean values and standard deviations when appropriate.

4. Findings

This section presents the descriptive statistical results obtained from 41 seafood enterprises in the Mekong Delta. The aggregated data are displayed through frequency tables, percentages, valid percentages, and illustrative charts. All comparisons between groups based on firm size and market orientation are descriptive in nature, intended to identify patterns within the survey sample, without implying statistical significance testing or causal inference.

4.1. Descriptive Statistics of the Research Sample

Regarding Job Position

Table 1 shows that there are 24 participants in the survey holding the position of Manager (accounting for 58.5%); followed by Logistics staff with 12 participants (accounting for 29.3%), and finally, Technical staff with 5 participants (accounting for 12.2%). The results indicate that Managers represent the highest proportion of survey participants, which helps ensure the effectiveness of the survey content.

Table 1 - Job Positions of Respondents within the Enterprise

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Manager	24	58.5	58.5	58.5
	Logistics staff	12	29.3	29.3	87.8
	Technical staff	5	12.2	12.2	100.0
	Total	41	100.0	100.0	

Years of Experience

Table 2 shows that the majority of survey participants have many years of experience in the aquatic industry. There are 38 individuals with over 5 years of experience, accounting for 92.7%, while those with 3 to 5 years of experience number 3, accounting for 7.3%. These results indicate that the participants possess adequate knowledge and experience to provide reliable information for the research.

Table 2 - Work Experience in the Seafood Industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	From 3 to 5 years	3	7.3	7.3	7.3
	Over 5 years	38	92.7	92.7	100.0
	Total	41	100.0	100.0	

Duration of Reverse Logistics Implementation by Enterprises

Table 3 shows that 43.9% of enterprises (18 enterprises) have been implementing reverse logistics for over 5 years; 39% (16 enterprises) have been implementing it for 3 to 5 years, and 14.6% (6 enterprises) for 1 to 3 years. Only 2.4% (1 enterprise) has implemented reverse logistics for less than 1 year. This indicates that most enterprises have several years of experience in applying reverse logistics processes within their operations.

Table 3 - Duration of Reverse Logistics Implementation by the Enterprise

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under 1 year	1	2.4	2.4	2.4
	From 1 to under 3 years	6	14.6	14.6	17.1
	From 3 to 5 years	16	39.0	39.0	56.1
	Over 5 years	18	43.9	43.9	100.0
	Total	41	100.0	100.0	

4.2. Challenges in Implementing Reverse Logistics and Achieved Effectiveness Level

4.2.1. Challenges in Implementing Reverse Logistics

The results from Table 4 show that all surveyed enterprises are facing significant challenges related to Product recovery, Recycling and waste treatment, and Storage and transportation of recovered products (accounting for 93.9% across all factors, with each factor representing 31.3%). Additionally, some enterprises face challenges regarding Costs (4 enterprises, accounting for 3.1%) and Data and information management (4 enterprises, accounting for 3.1%). This indicates that enterprises do not consider Costs and Data and information management to be major barriers in the process of implementing reverse logistics. Overall, enterprises encounter various challenges that are closely interconnected in the reverse logistics process. Issues related to the handling and reuse of used products also need to be addressed.

Table 4 - *Challenges in Implementing Reverse Logistics in Enterprises*

	Responses		Percent of Cases
	N	Percent	
Product recovery	41	31.3%	100.0%
Recycling and waste treatment	41	31.3%	100.0%
Storage and transportation of recovered products	41	31.3%	100.0%
Data and information management	4	3.1%	9.8%
Costs	4	3.1%	9.8%
Total	131	100.0%	319.5%

4.2.2. Effectiveness Level of Reverse Logistics

The analysis results from Table 5 show that 53.7% of participants (22 enterprises) rated the effectiveness level as 4 (Effective), while 19 enterprises rated it as 5 - Very Effective (accounting for 46.3%). No enterprises rated the effectiveness at any lower levels. This indicates that all participants believe that implementing reverse logistics brings benefits to their enterprises, contributing to enhanced operational effectiveness. This is essential for the goal of optimizing the enterprises' operational processes.

Table 5 - Evaluating the Effectiveness of Reverse Logistics in Enterprises

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	22	53.7	53.7	53.7
	5	19	46.3	46.3	100.0
	Total	41	100.0	100.0	

Note: level 4 being effective, and level 5 being very effective.

4.3. Current Status of AI Implementation in Aquatic Enterprises

Based on the results (Table 6), it indicates that the majority of enterprises have implemented AI in their reverse logistics operations (25 enterprises chosen, accounting for 61% of the total survey). Meanwhile, 16 enterprises are in the process of implementing AI in reverse logistics (accounting for 39.0% of the survey sample). This result shows that enterprises are very interested in and experienced in applying AI to their reverse logistics activities. Furthermore, even those enterprises currently implementing AI recognize the importance of integrating AI into their operations.

Table 6 - Applying AI in Reverse Logistics in Enterprises

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Implemented	25	61.0	61.0	61.0
	In progress	16	39.0	39.0	100.0
	Total	41	100.0	100.0	

4.3.1. Field of AI Application

The study indicates that the surveyed enterprises have applied AI in various fields within reverse logistics. This demonstrates the interest and efforts of enterprises to optimize processes and enhance operational efficiency. Specifically, Table 7 shows that enterprises implement AI in activities such as Forecasting product recovery demand, Optimizing storage and transportation, and Recycling and waste processing (each area accounting for 29.9%, with a total of approximately 89.7% of enterprises investing in AI in these fields). This result reflects that AI has become an effective tool for improving reverse logistics performance, helping enterprises optimize processes, minimize waste, and increase product value. For the area of Data and information management, 14 enterprises have applied AI (accounting for 10.2%). This result shows that enterprises are also very interested in Data and information management, in addition to other fields, indicating that they have recognized the importance of data management in supporting reverse logistics processes.

Table 7 - Field of AI Application in Reverse Logistics within Enterprises

		Responses		Percent of Cases
		N	Percent	
Field of AI Application	Forecasting product recovery demand	41	29.9%	100.0%
	Optimizing storage and transportation	41	29.9%	100.0%
	Data and information management	14	10.2%	34.1%
	Recycling and waste processing	41	29.9%	100.0%
Total		137	100.0%	334.1%

4.3.2. AI Technology Applied in Reverse Logistics

Table 8 - AI Technologies Applied in Reverse Logistics

		Responses		Percent of Cases
		N	Percent	
Technologies	Automatic product identification	20	24.1%	48.8%
	Real-time tracking of product recovery	37	44.6%	90.2%
	Intelligent recovery product classification system	26	31.3%	63.4%
Total		83	100.0%	202.4%

The survey results in Table 8 reveal that the AI technologies commonly used in the reverse logistics process within seafood enterprises show that “Real-time tracking of product recovery” has the highest proportion (44.6% with 37 enterprises applying it). This is followed by the “Intelligent recovery product classification system”, which accounts for 31.3% (chosen by 26 enterprises). Finally, the “Automatic product identification” technology accounts for 24.1% (with 20 enterprises choosing to use it). Although the study suggests other technologies, currently the surveyed enterprises have not adopted them. This result indicates the priority choices of enterprises in improving monitoring and management capabilities of the product recovery process, enhancing efficiency, and increasing transparency in the supply chain. Additionally, the results reflect that enterprises are increasingly focusing on optimizing the product classification process of used products, thereby improving recycling and waste management capabilities.

4.3.3. Effectiveness Level

According to the survey results (Table 9), 56.1% of enterprises evaluate the application of AI technologies in reverse logistics as “very effective” (23 enterprises). The remaining 43.9% (18 enterprises) perceive “effectiveness” when applying AI (achieving an effectiveness level of 4). In particular, the survey results also reveal that among the 23 enterprises that reported being highly effective, as many as 19 (accounting for 46.3%) assessed that the adoption of AI has enabled their companies to achieve greater efficiency. Meanwhile, the remaining small and medium-sized enterprises evaluated their performance as only moderately effective. This finding is consistent with real business practices, as medium and large enterprises typically possess stronger resource foundations than smaller ones. Therefore, their ability to apply technology and artificial intelligence in production processes to optimize efficiency is both logical and necessary. This indicates that all enterprises participating in the survey recognize that the application of AI in reverse logistics yields positive results for their units. Additionally, the study shows that all enterprises have a positive awareness of the role of AI in reverse logistics, providing long-term benefits for businesses and confirming that investing in AI technology in reverse logistics is a sound and strategic decision.

Table 9 - Effectiveness of AI Application in Reverse Logistics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	18	43.9	43.9	43.9
	5	23	56.1	56.1	100.0
	Total	41	100.0	100.0	

Note: level 4 being effective, and level 5 being very effective.

4.3.4. Time to Determine Effectiveness

Table 10 shows that seafood enterprises in the Mekong Delta region identify the time frame for AI effectiveness in reverse logistics, with the highest proportion being 51.2% (21 enterprises). Next, the period of 3 to 6 months accounts for 46.3% (19 enterprises) that perceive effectiveness. Finally, only 1 enterprise (2.4%) determines effectiveness within 6 to 9 months. This result indicates that the majority of enterprises assess AI technologies as effective immediately when applied to their reverse logistics processes. At the same time, enterprises recognize the feasibility and high applicability of AI technology in optimizing reverse logistics processes in the seafood industry. Furthermore, the application of AI also leads to significant improvements in a short period, reinforcing confidence in investing in this technology. However, a small number of enterprises believe that a longer time is needed to realize the benefits, but this number is very small compared to the overall total, indicating that most enterprises have had positive and rapid experiences from applying AI.

Table 10 - Time to Perceive Economic and Operational Effectiveness

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	From 1 to 3 months	21	51.2	51.2	51.2
	From 3 to 6 months	19	46.3	46.3	97.6
	From 6 to 9 months	1	2.4	2.4	100.0
	Total	41	100.0	100.0	

4.4. Benefits Gained from Applying AI Technology in Reverse Logistics Processes

4.4.1. Benefits Regarding Operating Costs

The analysis results from Table 11 show that 19 enterprises (46.3%) confirm that AI technologies applied in reverse logistics operations will reduce operating costs by over 10%. Next, 14 enterprises (34.1%) evaluate that this activity helps save operating costs by 7% to 10%. Additionally, 8 enterprises (19.5%) determine that they can cut operating costs by 5% to 7%. Overall, the results indicate that all enterprises participating in the survey have achieved positive efficiency in terms of operating costs after applying AI in their reverse logistics processes. This demonstrates that AI technology is highly effective in reverse logistics processes, highlighting the correctness of integrating technology into business operations.

Table 11 - Reducing Operating Costs Through AI Application

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	From 5% to 7%	8	19.5	19.5	19.5
	From 7% to 10%	14	34.1	34.1	53.7
	Above 10%	19	46.3	46.3	100.0
	Total	41	100.0	100.0	

4.4.2. Benefits Regarding Product Recovery Time

The analysis results (Table 12) show that up to 56.1% of enterprises evaluate that their company has minimized recovery time by over 10% (23 enterprises agree). Next, 34.1% of enterprises (14 enterprises) assess that they have saved 7% to 10% of recovery time. Finally, 4 enterprises (9.8%) believe they have saved recovery time by 5% to 7%. Overall, the results indicate that all enterprises have achieved very good efficiency in product recovery time, helping companies save time and costs in reverse logistics operations. This result demonstrates that the application of AI in reverse logistics processes significantly improves the product recovery time for enterprises, affirming that investment in AI technologies is appropriate.

Table 12. Time efficiency in product recall when applying AI

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	From 5% to 7%	4	9.8	9.8	9.8
	From 7% to 10%	14	34.1	34.1	43.9
	Above 10%	23	56.1	56.1	100.0
	Total	41	100.0	100.0	

4.4.3. Key Benefits Businesses Gain from Implementing AI

Results from Figure 5 indicate that the benefits businesses gain from applying AI in reverse logistics processes focus primarily on three groups of benefits as follows: Group 1 relates to "Minimize environmental impact", accounting for 30.1% of the benefit group; next is Group 2, which concerns benefits related to "Enhance operational efficiency", making up 29.4%; and Group 3, which pertains to benefits of "Reduce costs", comprises 27.9%. In addition to these benefit groups, during the implementation of AI in reverse logistics processes, seafood businesses also gain benefits in "Improve data management" (8.8%) and "Strengthen forecasting and planning capabilities" (3.7%). These results demonstrate that businesses primarily achieve sustainability, environmental, and efficiency benefits when applying AI, which aligns well with the sustainable development goals of society. Furthermore, benefits related to data management and forecasting capabilities could be enhanced by thoroughly applying AI technologies in the logistics process.

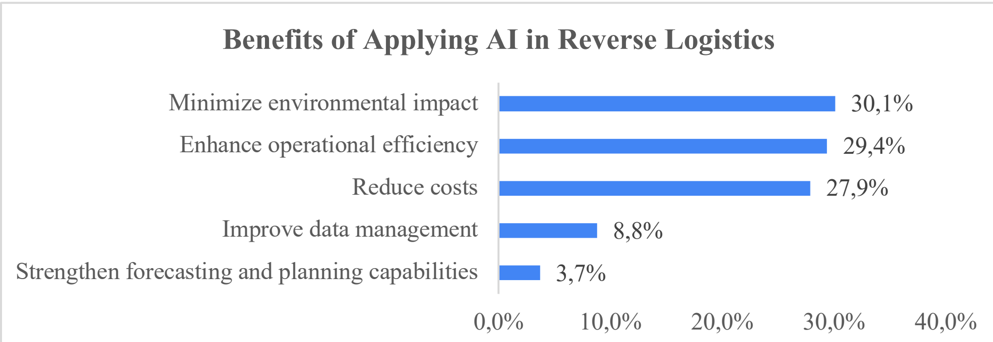

Fig. 5. Benefits of applying AI to reverse logistics

4.5. Assessing the Impacts of AI on Businesses

4.5.1. Impact on Environmental Protection in the Seafood Industry

The results from Figure 6 show that the factors related to the impact of AI in reverse logistics that contribute to environmental protection have a relatively even distribution, with three factors accounting for about 25% and one factor accounting for 23.4%. It can be concluded that no single factor significantly outweighs the others in terms of environmental protection for the seafood industry. Specifically, the factor related to "Reduce waste in the recovery process" accounts for 25.9%, highlighting the importance of optimizing the supply chain and effectively managing waste. The two factors "Help save energy" and "Optimize the transportation and storage system" both account for 25.3%, emphasizing the significance of efficient energy use, aligning with current sustainable development goals. Finally, the factor "Reduce emissions during transportation" accounts for 23.4%, indicating that reducing emissions is crucial in the transportation process for environmental protection. This underscores the necessity of investing in AI technologies in production processes to yield tangible environmental benefits for seafood businesses.

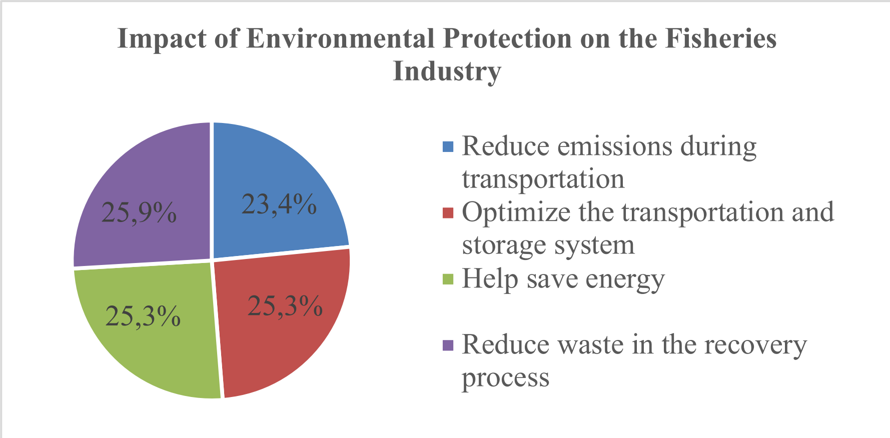

Fig. 6. Environmental impacts in the seafood industry

4.5.2. Impact on Human Resources

The analysis results (Figure 7) indicate that regarding human resources, AI has a significant impact related to the factors "Enhance the quality of human resources", "Change the way of working" and "Affect creativity and diversity in the workplace". Notably, the factor "Change employment" accounts for 1.8%, indicating that businesses believe the application of AI in reverse logistics does not significantly impact employment but rather plays a supportive role.

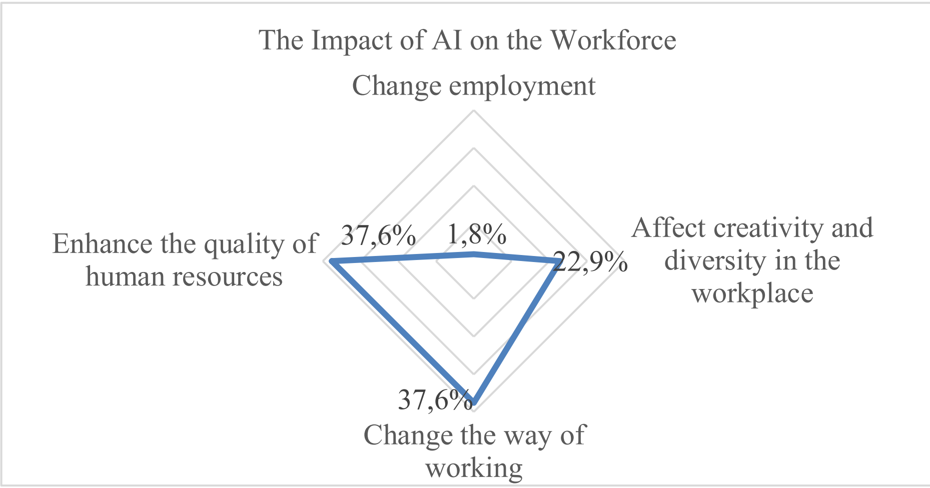

Fig. 7. The impacts of AI on the labor force in the seafood industry

Overall, AI changes the way people work (37.6%), which is reasonable as AI can automate many tasks today, forcing workers to change their mindset and adapt. At the same time, the research findings show that AI helps enhance the quality of human resources (37.6%) through training and skill development activities, aiding workers in improving their job efficiency. However, the research also indicates that 22.9% of businesses believe AI impacts creativity and diversity, potentially reducing personalization in the working process.

4.6. Challenges in Applying AI to Reverse Logistics Processes

Although businesses have implemented AI in their reverse logistics processes, they still face certain challenges, including technical, cultural, managerial, and ethical issues. Specifically, these challenges are as follows:

Technical Challenges

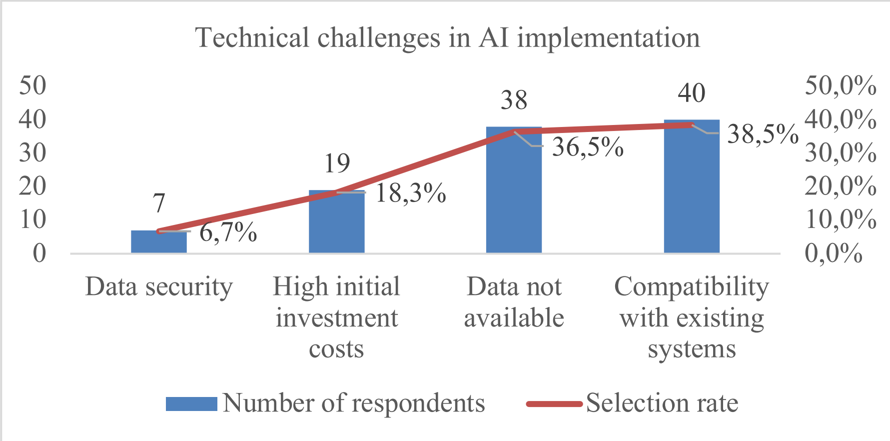

Fig. 8. *Technical challenges in implementing AI*

From a technical perspective, the analysis results in Figure 8 show that businesses primarily face challenges related to "Compatibility with existing systems" and "Data not available", with each factor accounting for 38.5% and 36.5%, respectively, in the survey results. Additionally, challenges related to "High initial investment costs" (18.3%) and "Data security" (6.7%) are also barriers affecting the process of applying AI in businesses. Overall, this research reflects the current situation, as most companies struggle with integrating old and new systems when implementing AI technology. At the same time, businesses also encounter issues related to the availability of data necessary for operations and activities.

Cultural Challenges

Table 13 shows that, from a cultural perspective within the organization, the results indicate that when implementing AI in the production process, businesses face significant challenges, particularly among employees. Specifically, 69.5% of respondents identified a lack of skills and knowledge regarding AI. This aligns with the fact that AI technologies have developed rapidly in recent years. Additionally, a certain percentage (30.5%) expressed concerns that AI could replace their jobs. These worries may lead to a lack of enthusiasm and create unnecessary barriers in the organization's digital transformation efforts. Furthermore, the study also highlights issues related to difficulties in organizing the application of AI and employee resistance to its implementation. However, businesses believe that these issues are not major challenges for organizational culture.

Table 13 - Organizational culture challenges commonly faced by businesses when adopting AI

		Responses		Percent of Cases
		N	Percent	
Cultural challenges	Employees lack skills and knowledge about AI	41	69.5%	100.0%
	Employees are concerned that AI applications will replace their jobs	18	30.5%	43.9%
Total		59	100.0%	143.9%

Challenges in Governance and Ethics

In terms of governance and ethics faced by businesses when implementing AI in reverse logistics, the results from Table 9 indicate that the factor "Transparency in data management" has the highest proportion at 36.9%. This is followed by "Legal barriers in the use of AI", which accounts for a significant 26.2%. Additionally, the challenge of "Privacy and cybersecurity" is also noteworthy, with 20.4% of participating businesses selecting this factor. Finally, the factor of "Ethical considerations when using AI" represents 16.5%. The analysis results demonstrate the necessity of strict compliance with procedures and the transparent handling of information. Furthermore, legal factors are also crucial when applying AI, given that many regulations are still not clearly defined. Measures for information security and customer rights are also important concerns alongside ethical standards when integrating AI technology into the logistics process.

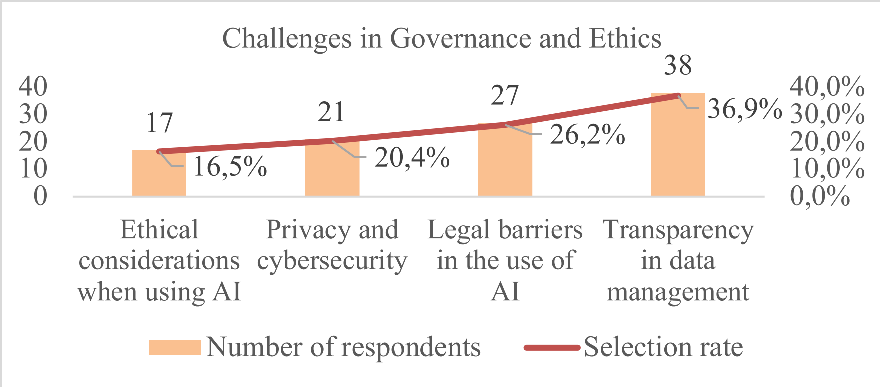

Fig. 9. Governance and ethical challenges in implementing AI

The findings reveal a multi-layered landscape of challenges in deploying AI for reverse logistics. On the technical side, difficulties with compatibility between new solutions and legacy systems (38.5%) and the lack of available data (36.5%) point to bottlenecks in digital infrastructure and data governance capacity; high upfront investment (18.3%) and data security concerns (6.7%) further elevate capital and operational risks. Culturally, 69.5% report insufficient AI skills and 30.5% fear job displacement, underscoring the need for reskilling, change communication, and redesigned roles rather than simple substitution of labor. In governance and ethics, data transparency (36.9%), legal barriers (26.2%), privacy and cybersecurity (20.4%), and ethical standards (16.5%) call for clear compliance frameworks, robust accountability mechanisms, and safe AI solutions that protect customer rights.

5. Discussion

5.1. Discussion

The results align with theoretical frames of reverse logistics and closed-loop supply chains, where traceability and intelligent sorting are prerequisites for value recovery and circularity (Prajapati et al., 2019; Mallick et al., 2023; Wilson et al., 2021). Survey evidence indicates a maturity path that begins with greater operational transparency, followed by expansion into advanced analytics. Regarding cost efficiency, 46.3% of firms report operating-cost reductions above 10%, 34.1% achieve 7–10%, and 19.5% reach 5–7%, reflecting a benefits profile skewed toward high performers due to routing and scheduling optimization. Payback is relatively quick: 51.2% perceive benefits within 1–3 months and 46.3% within 3–6 months. Environmental effects are also quantified: waste reduction 25.9%, energy savings 25.3%, transport and storage optimization 25.3%, and emissions cuts 23.4%, consistent with theoretical expectations about load consolidation, accurate sorting, and energy-aware operations.

The research results indicate that seafood enterprises in the Mekong Delta region gain numerous benefits regarding costs, product recovery time, and environmental impacts. However, there remain many difficulties and challenges in applying AI technologies in reverse logistics processes, such as challenges related to technology, culture, governance, and ethics. Therefore, businesses in the seafood industry need to fully leverage the advantages of AI tools to enhance efficiency while overcoming obstacles to optimize production processes and achieve business objectives.

First, companies need to establish processes and policies for handling and reusing products appropriately. At the same time, they should collaborate and connect with specialized recycling units to optimize waste treatment processes. On the other hand, to achieve high efficiency, businesses should also apply automation technologies and modern inventory management systems to improve the efficiency of product storage and distribution, thereby avoiding product spoilage during preservation. Additionally, while costs and data management are not major concerns for companies, the research also suggests that businesses should seek suitable suppliers to save costs and ensure data security, preventing the disclosure of business information.

Moreover, modern management systems will help companies effectively monitor and analyze logistics processes, allowing them to make appropriate strategic decisions.

Second, applying and integrating various AI technologies and collaborating with technology companies across different fields: Businesses need to integrate and widely implement multiple technologies in different areas, such as real-time tracking of product recovery and intelligent recovery product classification systems, to optimize monitoring and product classification processes. This activity enhances transparency in the supply chain and improves product recovery capabilities. Additionally, there should be a significant focus on technologies like automatic product identification to enable the automatic recognition of products, thus accelerating the processing of recovered products and minimizing errors. Furthermore, attention must be given to data management, as this is crucial for businesses to understand information clearly and make appropriate decisions for reverse logistics processes. Companies should also integrate related technologies, such as forecasting product recovery demand and optimizing storage and transportation, to save time and costs associated with product recovery. On the other hand, seafood enterprises should collaborate with technology companies to adopt modern AI technologies at reasonable costs to optimize their processes.

Third, focusing on environmental protection factors: The application of AI in reverse logistics in the seafood industry has provided numerous environmental benefits, such as reducing waste during recovery processes, saving energy, optimizing transportation and storage processes, and significantly decreasing emissions during transportation. Companies can invest in advanced AI tools to optimize reverse logistics processes and minimize waste. At the same time, AI can assist in forecasting and managing the supply chain, enabling businesses to recycle and reuse recovered products effectively. Additionally, AI tools can measure appropriate energy consumption during operations, utilizing energy resources only when necessary and reducing demand during peak periods. Finally, these AIs can coordinate transportation vehicles and identify suitable routes to minimize fuel consumption and automate emission reduction processes.

Fourth, investing in human resources in the field of AI: Businesses need to clearly define the important role of human resources in operations, specifically skilled personnel in the field of AI technology. Consequently, it is essential to provide regular training to enhance the professional qualifications and necessary skills of this workforce. Furthermore, frequent training sessions on flexible thinking, creativity, and the use of AI tools should be organized. These activities help workers become more confident in their jobs, encouraging them to change their mindset and embrace new working methods. At the same time, it is crucial to recognize that AI cannot fully replace humans; rather, it serves as a tool to support human activities and enhance labor productivity. This perspective will strengthen the relationship between humans and technology, alleviating concerns that AI will replace jobs. Companies should also encourage employees to develop thinking and creative skills in their work to avoid complete dependence on AI.

6. Conclusion

In order to improve visibility and decision quality, this study demonstrates how Mekong Delta seafood businesses are aggressively implementing AI in reverse logistics, particularly real-time recovery tracking, intelligent sorting, and automated identification. Quantitatively, businesses report significant performance improvements: most companies see a decrease in operating expenses, with a significant portion seeing reductions of over 10%; product recovery times also improve at comparable rates, with benefits being felt within one to six months. Environmental results are likewise measurable and balanced between reduced emissions, energy savings, trash reduction, and better transportation and storage. However, technological issues with old systems, data preparation gaps, and labor skill shortages, in addition to worries about privacy, transparency, and legal clarity, continue to make dissemination uneven. Overall, the results support AI's role in reverse logistics' efficiency, sustainability, and circularity while highlighting the necessity of phased data governance, focused reskilling, and strong compliance to turn pilots into scale effects.

Based on the research findings, applying AI can benefit aquatic companies, especially in their reverse logistics process. To be more effective in implementation, businesses can use AI to enhance their decision-making in forecasting supply and demand. It might lead to reduced waste and maximized profits. Moreover, AI can streamline the operation of business systems; it can optimize production scheduling and control seafood quality. Businesses can apply AI to monitor the environmental condition and aquatic product population in farming and harvesting. From this point, it can increase sustainable practices and attract eco-conscious customers. In addition, companies need to invest in training and developing knowledge and skills related to AI for their employees. It can ensure that the staff understands the importance and benefits of AI so they can be more confident in applying AI in their working process. These recommendations can be applied step by step, from training employees to implementing AI needed aspects of their business to improve the reverse logistics process.

Overall, the research has contributed to exploring the implementation of AI in reverse logistics, especially for seafood businesses in the Mekong Delta, which has received limited attention from previous researchers. However, the study also has certain limitations. Specifically, it focuses only on specific technologies, which affects the generalizability of the research findings to other AI technologies. Additionally, while the research identifies certain challenges faced by companies when applying AI in production, it does not address the solutions that companies have implemented to overcome these challenges. Moreover, the study has only concentrated on the seafood industry, so it is necessary to consider other industries and fields to comprehensively assess the impacts of AI on reverse logistics processes in companies.

From these limitations, future research should focus on expanding the exploration of AI applications in reverse logistics across various industries, beyond just the aquatic sector. Such studies will help enhance the generalizability of findings and clarify how different AI technologies impact reverse logistics processes. Additionally, subsequent research should carefully analyze the solutions that companies have implemented to overcome the challenges in applying AI in production processes, thereby providing valuable insights for developing effective AI application strategies. Finally, an interdisciplinary research approach, encompassing industries such as agriculture and manufacturing, will contribute to a more comprehensive assessment of AI's impact on reverse logistics processes, while also offering deep insights into how to optimize global supply chains through AI technology in production.

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Conflict of Interest
The authors declare no conflict of interest.

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