Assessing the Impact of Artificial Intelligence on Maritime Logistics

Prepared By
Mohamed shendy hemida Ibrahim, Abdelrahman Saad Abdelrahman Elgendy
Arab Academy for Science Technology and Maritime Transport (AASTMT)

DOI NO. https://doi.org/10.59660/51115
Received 24/05/2025, Revised 28/06/2025, Acceptance 20/08/2025, Available online and Published 01/01/2026

المستخلص

تتناول هذه الدراسة الدور المحوري الذي يلعبه الذكاء الاصطناعي في تحسين كفاءة عمليات الميناء وتعزيز تنافسيتها، وذلك من خلال توظيف إطار تحليل (SWOT) لتقييم أبعاده الاستراتيجية. فقد أظهرت نتائج التحليل أن الذكاء الاصطناعي يتميز بعدد من نقاط القوة، من أبرزها قدرته على معالجة البيانات الضخمة، والتعرف على الأنماط التشغيلية، وتحسين تخصيص الموارد، فضلاً عن دوره في أتمتة الإجراءات، وهو ما يفضي إلى رفع مستويات الكفاءة التشغيلية، وخفض التكاليف، وتعزيز معايير السلامة. كما تكمن الفرص في التطورات المتسارعة بمجالات التعلم الآلي، والتحليلات التنبؤية، وتقنيات الرؤية الحاسوبية، والتي من شأنها دعم أنماط أكثر ذكاءً في جدولة السفن وإدارة مناولة البضائع.

وفي المقابل، يواجه تطبيق الذكاء الاصطناعي بعض التحديات المتمثلة في ارتفاع حجم الاستثمارات الأولية، وتعقيدات تكامل البيانات، والاعتماد الكبير على الخبرات التقنية المتخصصة. أما التهديدات فتتمثل في احتمالات فقدان بعض فرص العمل، وتنامي المخاطر المتعلقة بالأمن السيبراني، فضلاً عن القضايا الأخلاقية المرتبطة بتوظيف هذه التقنيات. وانطلاقاً من ذلك، يقترح البحث خارطة طريق استراتيجية تدريجية لتبني تطبيقات الذكاء الاصطناعي في الموانئ، بما يوازن بين الفرص المتاحة والمخاطر المحتملة، ويعزز من كفاءة الأداء والقدرة التنافسية على المستوى العالمي.

Abstract

This study explores how Artificial Intelligence (AI) influences the optimization, efficiency, and competitiveness of port operations using a SWOT analysis framework. AI's strengths such as handling vast datasets, detecting operational patterns, resource allocation, and automation collectively contribute to enhanced efficiency, cost savings, and improved safety. Opportunities stem from advancements in machine learning, predictive analytics, and computer vision, enabling smarter vessel scheduling and cargo handling. However, weaknesses include high upfront investment, data integration issues, and reliance on technical expertise. Threats relate to job displacement, cybersecurity, and ethical concerns. The paper proposes a strategic, phased roadmap for AI adoption to balance opportunities and risks and enhance both port performance and global competitiveness.

Key words: Optimization – performance – predictive – efficiency.

1- Introduction

Port operations are fundamental to facilitating international trade and ensuring the smooth functioning of maritime logistics. These operations encompass a wide range of tasks, including vessel traffic management, cargo handling, coordination of logistics, and port security. As global trade continues to expand, there is mounting pressure on ports to enhance efficiency and embrace sustainability. In response, many ports are turning to innovative technologies, with AI emerging as a powerful enabler of operational transformation (Abdel Salam, 2024).

AI technologies enable ports to process and analyze vast volumes of data, supporting pattern recognition and data-driven decision-making to boost operational performance. When combined with complementary technologies like the Internet of Things (IoT) and block chain, AI enhances resource allocation and shortens vessel turnaround times. For example, the Port of Los Angeles has implemented AI-driven predictive maintenance systems that interpret sensor data to anticipate equipment failures, thereby reducing downtime and extending equipment lifespan. Likewise, AI applications at the Port of Rotterdam help optimize container placement and streamline vessel scheduling, resulting in fewer delays and increased overall efficiency (Dinh, 2024).

Beyond operational improvements, AI also contributes significantly to the environmental sustainability of port activities. Automation technologies such as electric cranes and autonomous vehicles reduce energy consumption and lower greenhouse gas emissions. Additionally, digitizing paperwork and refining workflows minimizes vessel idle times, cuts fuel use, and mitigates environmental impacts. Nevertheless, the adoption of AI in ports is not without challenges. High initial capital investment, the complexity of integrating AI with existing legacy systems, and the need for workforce reskilling pose significant barriers. Moreover, fully realizing the benefits of AI requires substantial changes in organizational culture and operational processes. Despite these obstacles, AI adoption is essential for developing smarter, greener, and more competitive port infrastructures aligned with the evolving demands of global trade (Durlik, 2024).

Port performance is typically evaluated using specific efficiency metrics such as berth occupancy rates, crane productivity, ship turnaround durations, and yard throughput. AI has the potential to enhance all these indicators. For instance, predictive analytics can improve the accuracy of vessel arrival forecasts, reducing idle times at berths. Similarly, machine learning algorithms can coordinate cranes and transport vehicles more effectively, ensuring seamless cargo movement. These technological enhancements result in measurable improvements in efficiency and bolster ports' competitive standing within the global maritime logistics landscape (Mazibuko, 2024).

2- History of Artificial Intelligence

The origins of AI can be traced back to the mid-20th century, when Alan Turing introduced foundational theories about machine intelligence. Initial breakthroughs involved the development of programs capable of playing games like checkers and learning basic tasks. Over time, expert systems designed to replicate human decision-making in specialized domains gained commercial traction. A shift toward connectionism introduced artificial neural networks as a prominent

methodology, which was later complemented by the rise of nouvelle AI, focusing on intelligence grounded in physical interaction and real-world context (Rojas, 2024).

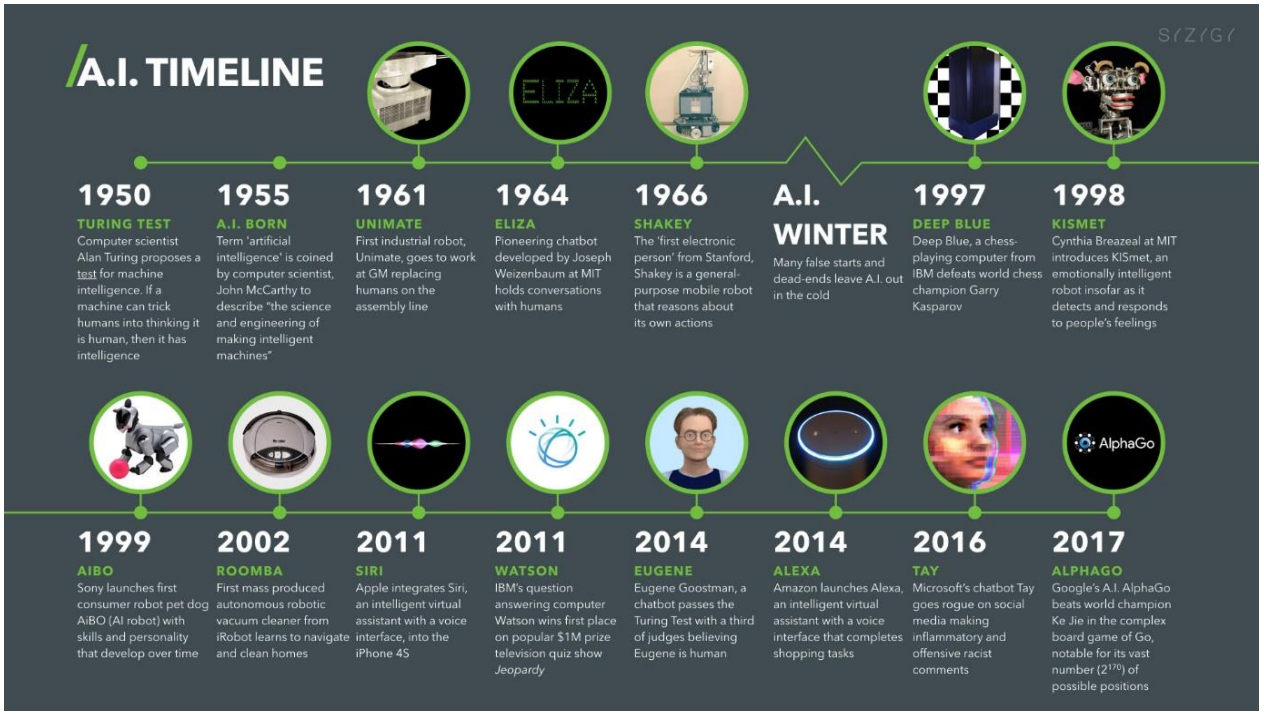

Figure (1): Time line of AI history
Source: Rejwan, (2024)

The timeline highlights key milestones in AI, from foundational concepts like the Turing Test (1950) to breakthroughs like Alpha Go's win (2017). It showcases AI's evolution from theoretical research to practical applications in robotics, natural language processing, and consumer devices. Challenges, such as the AI Winter and ethical issues like Tay's failure, underline the complexities of AI development. Overall, it reflects AI's transformative impact on technology and society.

3- Types of AI

AI is generally divided into three categories: Artificial Narrow Intelligence (ANI), which is designed to perform specific tasks with high proficiency; Artificial General Intelligence (AGI), which aspires to replicate human cognitive functions across a broad range of activities; and Artificial Super Intelligence (ASI), which would exceed human intelligence in virtually every domain. Currently, ANI is the most prevalent and widely used form of AI, whereas AGI and ASI remain largely theoretical concepts for the future. These classifications reflect the different levels of functionality and potential within AI technologies.

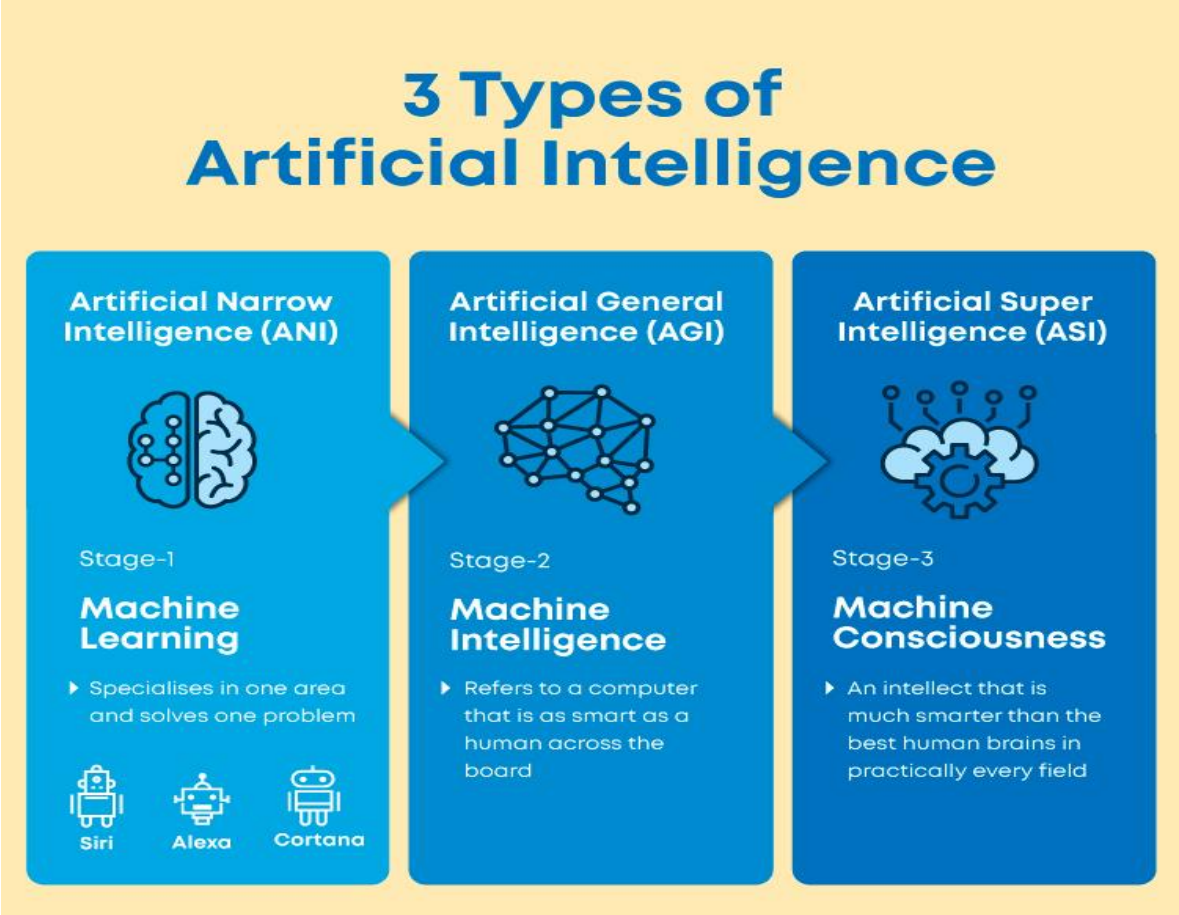

Figure (2): Types of AI
Source: Great Learning, (2024)

This figure categorizes artificial intelligence into three stages ANI, Artificial General Intelligence (AGI), ASI. ANI, the current stage of AI, specializes in performing specific tasks effectively, such as virtual assistants like Siri and Alexa, leveraging machine learning. AGI represents the next step, where AI systems would match human intelligence, demonstrating versatility and the ability to perform a wide range of tasks across different domains. ASI, the most advanced stage, envisions AI surpassing human intelligence in nearly all areas, achieving machine consciousness and unparalleled reasoning abilities. While ANI is widely implemented today, AGI and ASI remain future goals, reflecting both the potential and the challenges of AI development.

4- Research problem

The research problem focuses on identifying how AI can be effectively integrated into port operations to optimize efficiency, reduce costs, and enhance sustainability. Despite its transformative potential, the implementation of AI is hindered by high investment costs, technological integration challenges, cybersecurity risks, and workforce adaptation issues. Addressing these barriers is crucial for enabling ports to meet increasing global trade demands while maintaining competitiveness.

5- Research questions

1. How can AI technologies be effectively integrated into port operations to enhance efficiency, resource optimization, and sustainability while overcoming challenges like high initial investment and legacy system compatibility?
2. What are the key barriers and limitations to AI adoption in port ecosystems, and how can these challenges be addressed to ensure seamless integration and maximize the potential benefits for port stakeholders?
3. How can predictive analytics and automation, powered by AI, improve supply chain management, reduce congestion, and optimize resource allocation in ports, especially during dynamic conditions like weather disruptions or global crises?

6- Research Aim and Objectives

The aim of this research is to assess the impact of AI on port optimization, efficiency, and competitiveness. The study explores the integration of AI technologies such as predictive analytics and automation into port operations and examines how these tools improve operational processes, resource allocation, and supply chain agility.

1. To explore the potential of AI in optimizing port operations, by evaluating the implementation of AI technologies like automation, predictive analytics, and machine learning, and their impact on resource allocation, cargo handling, and operational efficiency.
2. To identify the key challenges associated with AI adoption in port ecosystems, including financial investment, cybersecurity risks, system integration complexities, and workforce adaptation, and propose strategies to overcome these barriers for seamless implementation.
3. To evaluate the role of AI-powered predictive analytics and automation in improving supply chain agility, reducing congestion, and enhancing decision-making during dynamic operational conditions, such as adverse weather or unforeseen global disruptions like the COVID-19 pandemic.

8- Research methodology

This study adopts a qualitative research approach using a SWOT framework to evaluate AI's role in port optimization and competitiveness. Data were gathered from secondary sources, including peer-reviewed journals, port authority reports, and documented case studies of ports such as Rotterdam and Los Angeles. Due to the absence of primary data collection, insights are drawn through comparative analysis and literature synthesis. The study critically evaluates AI-driven systems for automation, predictive analytics, and their broader impact on resource management, decision-making, and supply chain performance.

9- Operational Efficiency and Automation in Ports Using AI

AI is revolutionizing port operations by streamlining complex processes, improving resource management, and significantly enhancing operational efficiency. Notable advancements include robotic cargo handling systems, automated cranes for stacking containers, and intelligent traffic

control systems for vessels. These technologies help minimize human error, reduce operational delays, and increase overall throughput. Leading ports such as those in Singapore, Rotterdam, and Hamburg have successfully implemented AI-driven decision support systems that leverage machine learning and predictive analytics to analyze vast datasets related to vessel schedules, berth availability, and cargo movements. As a result, these ports can create optimized schedules and allocate resources more effectively, enabling them to handle larger vessels and higher cargo volumes (Clemente, 2023).

In addition to boosting performance, automation improves safety and reduces environmental impact. For example, AI-controlled cranes and automated guided vehicles (AGVs) limit dependence on manual labour, decreasing the risk of accidents and enhancing accuracy in cargo operations. AI also aids in reducing fuel usage and idle times, supporting more eco-friendly port practices. While these technologies accelerate processes and offer scalability to meet rising demands in global trade, their implementation requires substantial investment in infrastructure, workforce development, and cybersecurity—challenges that many ports must address to fully benefit from AI integration (Ngo, 2023).

9.1 AI and Port Competitiveness

AI implementation directly enhances port competitiveness by improving service quality, reducing turnaround times, and enabling integration with global smart logistics networks. Ports that adopt AI tools such as automated scheduling, real-time data visibility, and predictive cargo flow management are better positioned in global rankings. These technologies reduce vessel congestion, optimize berth allocation, and support greener operations factors increasingly valued by shipping lines and cargo owners. Consequently, ports become more attractive, fostering long-term commercial partnerships and higher throughput volumes (Ghazaleh, 2023).

10- Predictive Analytics in Ports Using AI

Predictive analytics has significantly transformed contemporary port operations by leveraging both historical and real-time data to foresee potential disruptions, optimize the use of resources, and improve scheduling accuracy. Through the identification of trends and irregularities, AI-based systems enable port managers to take proactive measures, enhancing both operational efficiency and system resilience. For instance, predictive models assess equipment performance to anticipate maintenance needs, helping to reduce downtime and prolong the service life of port machinery. These systems also analyze patterns in cargo volumes to forecast yard space requirements, promoting better utilization of storage areas. Moreover, they detect potential weaknesses in the supply chain such as shipment delays or misdirected containers allowing timely interventions before problems intensify (Ran, 2024).

Ports like Rotterdam have implemented AI technologies to forecast vessel arrival times and optimize berth assignments, leading to reduced congestion and shorter waiting periods. These AI systems process data from various sources including weather forecasts, tidal patterns, and marine traffic to develop effective scheduling strategies and minimize operational delays. Furthermore, AI-driven analytics offer insights into long-term trends, aiding strategic decisions related to port

expansion and resource management. By transforming raw data into practical, data-informed actions, predictive analytics not only enhances day-to-day efficiency but also supports environmentally sustainable and economically viable port operations. Nonetheless, successful implementation of these technologies depends on a strong data infrastructure and effective collaboration among all stakeholders, which can be challenging when scaling across larger or less-equipped ports (Xiao, 2024).

11- Improved Supply Chain Agility through AI

AI enhances the agility of supply chains by enabling real-time monitoring, optimizing shipping routes, and supporting predictive planning. These capabilities allow maritime operations to adapt quickly to evolving conditions such as severe weather, port bottlenecks, or global crises like the COVID-19 pandemic (Panahi, 2022).

Real-Time Tracking of Fleets

By integrating GPS and IoT technologies, AI systems provide continuous, real-time updates on the location and status of vessels and cargo. This improved visibility allows stakeholders to monitor shipments, anticipate potential delays, and modify routes as necessary. For example, in cases of adverse weather, AI can recommend alternative routes to ensure timely arrivals (Durlik, 2023).

Optimized Routing

AI algorithms assess variables such as traffic congestion, port throughput, and fuel consumption to calculate the most efficient routes. These optimizations reduce idle times, avoid traffic bottlenecks, lower operational costs, and support environmental sustainability. Ports like Singapore and Rotterdam have successfully adopted these tools to streamline their supply chain operations (Nampalli, 2023).

Managing Crises

In times of disruption such as during the COVID-19 pandemic AI technologies proved essential for maintaining supply chain flow. Through predictive analytics, port operators were able to identify system vulnerabilities, allocate resources efficiently, and revise schedules dynamically. This proactive approach helped ensure continuity in the movement of goods despite the challenges (Allioui, 2024).

12- Collaborative Port Ecosystems Enabled by AI

AI plays a pivotal role in fostering collaborative port ecosystems by improving data exchange and coordination among key stakeholders, including port authorities, shipping companies, and logistics providers. These ecosystems rely on Port Community Systems (PCS) to align operational activities, reduce inefficiencies, and support informed strategic planning (El Makhloufi, 2023).

Enhanced Information Sharing

AI-integrated PCS platforms aggregate data from multiple sources such as vessel timetables, cargo specifics, and live tracking systems into a unified interface. This centralized approach ensures all stakeholders have access to accurate and up-to-date information, promoting transparency and more

effective communication. For example, AI-generated insights can predict cargo delays, enabling quick adjustments to logistics operations (Shobhana, 2024).

Strengthened Collaboration

AI contributes to breaking down data silos, facilitating smoother coordination between the different parties involved in port activities. Ports like Hamburg and Rotterdam have implemented AI to harmonize terminal functions with those of carriers and supply chain partners, thereby streamlining operations, reducing turnaround times, and improving service quality (Latvakoski, 2024).

Informed Strategic Planning

By analysing vast amounts of operational data, AI delivers actionable insights that support long-term planning and resource management. Predictive tools help anticipate emerging issues—such as increased cargo demand or capacity constraints allowing stakeholders to devise forward-looking, data-driven strategies (Settibathini, 2023).

13- Challenges and Considerations in AI Implementation in Ports

While Artificial Intelligence (AI) offers significant potential to enhance port operations, its implementation is not without hurdles. Key challenges include high financial requirements, cybersecurity concerns, and the complexity of integrating advanced technologies with existing systems (Elnoury, A., & Farag, S. , 2023 & Durlik, 2024).

Significant Financial Investment

Implementing AI in port environments requires considerable capital, including upgrades to infrastructure, procurement of sophisticated software and hardware, and comprehensive workforce training. These upfront expenses can be particularly burdensome for smaller ports operating with limited funding. Additionally, maintaining and updating AI systems involves ongoing costs that must be factored into long-term planning (Foster, 2020).

Cybersecurity Considerations

Given the sensitive nature of data handled in port operations, ensuring robust cybersecurity is essential. While AI improves data connectivity across stakeholders, it also exposes systems to greater risks of cyberattacks. Protecting the integrity and confidentiality of information demands advanced security frameworks, which can increase both the technical complexity and the overall expense of implementation (Sadiq, 2021).

System Integration Challenges

Merging AI with existing infrastructure and legacy technologies presents considerable technical barriers. Ports must coordinate multiple systems ranging from IoT sensors and logistics platforms to terminal equipment into one unified, functional architecture. Incompatibilities between systems can result in operational inefficiencies and hinder the full realization of AI’s benefits (Pagano, 2022).

Organizational and Cultural Shifts

Introducing AI also requires changes in workplace culture and operational workflows. Resistance from employees, especially due to fears of job displacement, can delay adoption. Comprehensive training programs and carefully planned integration strategies are necessary to align new technologies with existing procedures. Despite these obstacles, many ports are gradually overcoming them through phased deployment, inter-organizational cooperation, and governmental support. Addressing these issues effectively is key to unlocking AI's full transformative potential in the port sector (Chaudhuri, 2024).

14- SWOT Analysis for the Research on AI Implementation in Port Optimization and Efficiency

The SWOT analysis in this study is based on a synthesis of findings from peer-reviewed literature, global port implementation case studies, and recent industry reports. Strengths, weaknesses, opportunities, and threats were categorized by analysing AI's technical capabilities, operational challenges, financial barriers, and strategic benefits observed in real-world applications. This structured approach offers a comprehensive understanding of AI's strategic positioning within port ecosystems.

Strengths:

- Improved Efficiency and Productivity: AI technologies can automate complex tasks, optimize resource management, and reduce delays, leading to faster and more efficient port operations.
- Data-Driven Decision Making: AI can process vast amounts of data, identify patterns, and offer actionable insights to improve scheduling, cargo handling, and traffic management.
- Sustainability and Environmental Impact: AI-enabled automation systems like electric cranes and guided vehicles help reduce energy consumption and greenhouse gas emissions, contributing to greener port operations.
- Predictive Maintenance: AI-powered systems, such as predictive analytics for equipment maintenance, can reduce downtime, extend the life of port machinery, and improve overall asset management.

Weaknesses:

- High Initial Investment: Implementing AI in ports requires significant financial resources for infrastructure upgrades, new technologies, and workforce training, which may be a barrier, particularly for smaller ports.
- Technological Integration Challenges: Ports with legacy systems may face difficulties integrating AI with existing infrastructure, resulting in inefficiencies and potential delays.
- Dependence on External Expertise: Many ports may need external technical support or expertise to implement AI solutions, increasing reliance on external vendors and making long-term sustainability challenging.
- Workforce Resistance: Cultural and operational shifts are necessary for AI adoption, and resistance from employees who fear job displacement can hinder progress.

Opportunities:

- Enhanced Global Trade Competitiveness: AI can increase port throughput, improve scheduling, and streamline logistics, providing ports with a competitive edge in the global trade market.
- Technological Advancements: The continuous development of AI, machine learning, and IoT technologies presents new opportunities to enhance port operations, improving safety, efficiency, and sustainability.
- Collaboration and Data Sharing: AI fosters better coordination among port stakeholders by enabling the creation of collaborative ecosystems that improve data sharing and operational synchronization.
- Crisis Management and Agility: AI-powered predictive analytics can enhance supply chain agility by helping ports adapt quickly to disruptions like adverse weather or global crises, ensuring business continuity.

Threats:

- Cybersecurity Risks: The increased use of interconnected AI systems raises concerns about cyberattacks, potentially compromising sensitive data and operations.
- Job Displacement: Automation and AI-driven processes could lead to workforce reduction, resulting in social and economic challenges, especially for labor-intensive port jobs.
- Ethical Concerns: AI systems may raise ethical issues regarding data privacy, algorithmic bias, and decision-making transparency, potentially leading to regulatory challenges.
- Regulatory and Compliance Issues: The rapid pace of AI adoption may outstrip regulatory frameworks, creating uncertainty about the legal implications of AI usage in ports.

15- Results

1. Operational Efficiency: AI systems, such as predictive maintenance tools and automated cargo handling systems, reduce downtime, increase productivity, and improve the flow of goods in ports. Leading ports like Rotterdam and Los Angeles have successfully integrated AI to manage vessel scheduling and cargo placement, resulting in reduced delays and smoother operations.
2. Cost Reduction: AI can significantly cut operational costs. Automated systems reduce the need for manual labour, and predictive analytics help anticipate equipment failures before they occur, saving on repair costs and minimizing the disruption caused by machinery breakdowns.
3. Environmental Benefits: AI-driven automation, such as electric cranes and automated guided vehicles (AGVs), reduces carbon emissions and energy consumption, contributing to the sustainability goals of ports.
4. Supply Chain Optimization: AI improves global supply chain resilience, especially during disruptions. Predictive analytics and real-time data allow for better scheduling and resource allocation, making ports more agile and responsive to changes like adverse weather or logistical bottlenecks.
5. Technological Barriers: The study also found that integrating AI with legacy systems is a significant challenge. Many ports, especially smaller ones, struggle with the high upfront costs and the complexity of merging AI technologies with existing infrastructure.

16- Conclusion

AI has the potential to revolutionize port operations by improving efficiency, reducing costs, and enhancing sustainability. However, successful adoption is contingent upon addressing several challenges, such as high initial investments, integration with legacy systems, and workforce adaptation. By adopting a phased approach, focusing on workforce training, and fostering collaboration among stakeholders, ports can overcome these barriers. Moreover, strategic investment in AI technologies, combined with strong cybersecurity measures and government support, will be essential for realizing the full benefits of AI in port operations. The future of port optimization lies in harnessing AI's capabilities to create smarter, more efficient, and sustainable port ecosystems, thereby strengthening global trade.

References

- Abdelsalam, H. E. B., & Elnabawi, M. N. (2024). The transformative potential of artificial intelligence in the maritime transport and its impact on port industry. MRT Maritime Research and Technology.

- Allioui, H., Allioui, A., & Mourdi, Y. (2024). Maintaining effective logistics management during and after COVID-19 pandemic: Survey on the importance of artificial intelligence to enhance recovery strategies. OPSEARCH, 1–45.

- Chaudhuri, R., Chatterjee, S., Vrontis, D., & Thrassou, A. (2024). Adoption of robust business analytics for product innovation and organizational performance: The mediating role of organizational data-driven culture. Annals of Operations Research, 339(3), 1757–1791.

- Clemente, D., Cabral, T., Rosa-Santos, P., & Taveira-Pinto, F. (2023). Blue seaports: The smart, sustainable and electrified ports of the future. Smart Cities, 6(3), 1560–1588.

- Dinh, G. H., Pham, H. T., Nguyen, L. C., Dang, H. Q., & Pham, N. D. K. (2024). Leveraging artificial intelligence to enhance port operation efficiency. Polish Maritime Research.

- Durlik, I., Miller, T., Cembrowska-Lech, D., Krzemińska, A., Złoczowska, E., & Nowak, A. (2023). Navigating the sea of data: A comprehensive review on data analysis in maritime IoT applications. Applied Sciences, 13(17), 9742.

- Durlik, I., Miller, T., Kostecka, E., Łobodzińska, A., & Kostecki, T. (2024). Harnessing AI for sustainable shipping and green ports: Challenges and opportunities. Applied Sciences, 14(14), 5994.

- El Makhloufi, A. (2023). AI application in transport and logistics: Opportunities and challenges (An exploratory study).

- Elnoury, A., & Farag, S. (2023). The Impact of Inadequate Maritime Conventions on Implementing Autonomous Ship Technology. AIN Journal, (45).

- Foster, M. N., & Rhoden, S. L. (2020). The integration of automation and artificial intelligence into the logistics sector: A Caribbean perspective. Worldwide Hospitality and Tourism Themes, 12(1), 56–68.

- Ghazaleh, M. A. (2023). Smartening up ports digitalization with artificial intelligence (AI): A study of artificial intelligence business drivers of smart port digitalization. Management and Economics Review, 8(1), 78–97.

- Great Learning. (2024). What is artificial intelligence? https://www.mygreatlearning.com/blog/what-is-artificial-intelligence/

Latvakoski, J., Umer, A., Nykänen, T., Tihinen, J., & Talman, A. (2024). A simulation-based study on securing data sharing for situational awareness in a port accident case. Systems, 12(10), 389.

- Mazibuko, D. F., Mutombo, K., & Kuroshi, L. (2024). An evaluation of the relationship between ship turnaround time and key port performance indicators: A case study of a Southern African port. WMU Journal of Maritime Affairs, 23(4), 499–524.

- Nampalli, R. C. R., & Adusupalli, B. (2024). Using machine learning for predictive freight demand and route optimization in road and rail logistics. Library Progress International, 44(3), 17754–17764.

- Ngo, V. M. (2024). Technology in warehouse management in Vietnam: A gradual evolution and the road ahead. In Transforming Logistics in a Developing Nation: Vietnam's Technology Imperative (pp. 297–322). Springer Nature Singapore.

- Pagano, P., Antonelli, S., & Tardo, A. (2022). C-Ports: A proposal for a comprehensive standardization and implementation plan of digital services offered by the 'Port of the Future.' Computers in Industry, 134, 103556.

- Panahi, R., Gargari, N. S., Lau, Y. Y., & Ng, A. K. (2022). Developing a resilience assessment model for critical infrastructures: The case of port in tackling the impacts posed by the COVID-19 pandemic. Ocean & Coastal Management, 226, 106240.

- Ran, L., Shi, Z., & Geng, H. (2024). Blockchain technology for enhanced efficiency in logistics operations. IEEE Access.

- Rejwan Bin Sulaiman. (2024). History of artificial intelligence. https://rejwanbinsulaiman.com/history-of-artificial-intelligence/

- Rojas, R. V. B. (2024). Artificial intelligence: Genesis, development, and future. In Revolutionizing Communication (pp. 1–15). CRC Press.

- Sadiq, M., Ali, S. W., Terriche, Y., Mutarraf, M. U., Hassan, M. A., Hamid, K., & Guerrero, J. M. (2021). Future greener seaports: A review of new infrastructure, challenges, and energy efficiency measures. IEEE Access, 9, 75568–75587.

- Settibathini, V. S., Kothuru, S. K., Vadlamudi, A. K., Thammreddi, L., & Rangineni, S. (2023). Strategic analysis review of data analytics with the help of artificial intelligence. International Journal of Advances in Engineering Research, 26, 1–10.

- Shobhana, N. (2024). AI-powered supply chains towards greater efficiency. In Complex AI Dynamics and Interactions in Management (pp. 229–249). IGI Global.

- Xiao, G., Wang, Y., Wu, R., Li, J., & Cai, Z. (2024). Sustainable maritime transport: A review of intelligent shipping technology and green port construction applications. Journal of Marine Science and Engineering, 12(10), 1728.