

Impact of Port Automation and Vessel Traffic in Calabar Sea Port.

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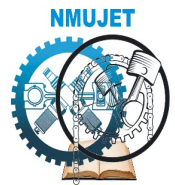
Abstract

This study examines the relationship between Port Automation and Vessel Traffic in Calabar Sea Port. The study seeks to identify key factors that impact on the efficiency of sea port, including the port cargo handling facilities, Vessel type and size and regulatory influences. This study collected data through the use of a structured questionnaire and survey method, specifically employing a cross-sectional investigation approach. The study's population consisted of the staff of NPA and Terminal Operators, with a sample size of 350. The Spearman Rank Correlation Coefficient was employed to evaluate the hypotheses of the empirical investigation. The results indicated that the presence of Lack of automated cargo handling equipment, will negatively affect Calabar Port operations and productivity well-maintained and up-to-date port infrastructure, such as berths and cargo handling facilities, has a substantial impact in minimizing delays during the berthing process. According to the results, it is recommended that port authorities along with pertinent government agencies give priority to investments in contemporary cargo handling machinery, berths, quays, and yard facilities. This encompasses routine maintenance to ensure the highest level of functionality. Ports should contemplate the possibility of extending their operational hours to facilitate both daytime and nighttime activities. Nevertheless, it is imperative to tackle the security, customs, and workforce-related obstacles linked to nighttime operations.

Keywords: Port automation, Vessel traffic, Sea Port, Port cargo handling facilities, Calabar

Introduction

Port automation is changing the way cargoes are handled, increasing productivity and streamlining processes. Port automation is the use of advanced technology and robotics to automate various aspects of port operations. These technologies include robotic container handlers, automated cranes, and intelligent conveyor systems and discharge operations. Replacing manual labor with automated systems can significantly increase port efficiency and reduce the risk of accidents (George & Camille., 2023). One of the key elements of port automation is the use of automated guided vehicles (AGVs) to transport containers within ports. These AGVs are equipped with sensors and navigation systems, allowing



them to navigate within ports without human intervention. We can transport containers from ships to storage sites and vice versa, ensuring that the entire process runs smoothly and efficiently. Another important aspect of port automation is the implementation of intelligent systems that can monitor container movements in real time. These systems use sensors and data analytics to determine the location, condition, and status of containers, providing accurate and timely information to port operators and shippers. This allows you to make informed decisions and optimize the flow of cargoes through the ports (Lun et al., 2010).

Contrary to popular belief, port automation does not completely eliminate the need for human involvement. Instead, a collaborative approach is encouraged, where humans and machines complement each other's strengths. Machines perform repetitive and physically demanding tasks, while humans provide the critical thinking, creativity, and adaptability necessary for complex decision-making and problem-solving. In automated ports, people play an important role in monitoring and controlling the operation of automated systems (Okeudo, 2013). It is your responsibility to monitor the performance of your machine, ensure that it is functioning properly, and correct any problems that may arise. Additionally, port managers provide the expertise and knowledge needed to make strategic decisions and optimize the overall performance of their respective sea ports. Port automation has a significant impact on the efficiency and productivity of port operations. By replacing manual labor with automated systems, ports can achieve higher throughput rates, reduce operational costs, and improve overall performance. Additionally, port automation improves security (Malnatchi, 2023).

Automated systems can handle hazardous and heavy objects accurately and carefully, reducing the risk of accidents and injuries. Intelligent systems and sensors enable real-time monitoring of container movement, ensuring goods are tracked and secured throughout the process. This not only protects your cargo, but also helps prevent theft and smuggling. In addition to efficiency and productivity benefits, port automation also promotes sustainability and environmental responsibility through the use of green technologies. Automated ports are at the forefront of implementing green practices and technologies that minimize carbon emissions and reduce environmental impact (Banomyong 2005). One of the most important environmentally friendly technologies in automatic ports is the use of electric devices. By replacing diesel-powered machinery with alternative electrical equipment, ports can significantly reduce air pollution and noise



levels. Electric cranes, AGVs and other equipment produce no emissions on site, making them a cleaner, quieter alternative. Another green technology in automated ports is the integration of renewable energy sources. The port is considering the use of solar panels, wind turbines and other renewable energy systems to power its operations. These energy sources can reduce dependence on fossil fuels, reduce greenhouse gas emissions and contribute to a more sustainable energy mix. Additionally, automated systems enable better energy management and optimization (Nottebom et al, 2022).

The impact of the corona-virus pandemic (COVID-19) is occurring domestically and internationally, affecting shipping operations. Despite borders being closed to the movement of people, the movement of goods across borders, such as food and medicine, remains important. The virus is driving the use of automated cargo handling equipment in cargo operations in major sea ports in the world and it is also driving force the use of autonomous computer controls in the maritime sector (Nwokedi,et al., 2019). In some ports, this technology allows crane operators to work from remote Play Stations, allowing automated cranes to move containers at ports with minimal worker control or with workers controlling computers. Advances in telecommunications, originally developed for toy scale models, enable remote control of ships in port areas. Despite quarantine restrictions, a portion of the population is essential workers who must report to work to provide services that keep the community functioning. Those at the forefront of automation can work from home with their colleagues to develop future autonomous transport technologies, including transport operations directly and indirectly involved in ports and ships (Magdiel et. al 2023).

Seaport cargo handling capacity is highly dependent on the volume of shipping traffic and the size of ships calling at the port. Port authorities also need to implement strategic management tools to achieve higher cargo throughput. Sustainable measurement of minimum port performance can be achieved by establishing benchmarks to remain competitive in business in terms of port revenue growth, vessel traffic, etc (Nwokedi et al., 2019).

According to Kiwanuka (2013), before entering or leaving the port, a local boat pilot who is familiar with the local navigational conditions will board the boat and guide the boat safely to and from the pier. Due to the risk of virus infection among ship passengers, attention is being focused on autonomous pilotage services and remote pilotage services in which a local pilot stationed at a workstation on land remotely monitors ships entering



and leaving port. One possibility is for a port-based drone to fly to a landing pad atop the ship's control bridge. When mounted on a bridge, it connects to the ship's navigation system. A series of strategically placed cameras allows land-based pilots to view from the bridge as if they were actually on board the ship. A moving laser strategically placed toward a distant lens could transmit information through the atmosphere. This transmission of "line of sight" between the ship and the shore significantly reduces the ability of outsiders to access the ship's navigational controls. Within port areas, seawater can transmit sonar signals at specific frequencies between ships and the shore, facilitating the exchange of navigational information (Daniela, 2020)

Kon. et. al. (2020), the pandemic has placed a renewed emphasis on automated container handling port operations using automated cranes, automated rubber-tire port vehicles, and automated port rail operations. While rail operations have traditionally relied on above-ground tracks, recent innovations in overhead line technology offer the potential to further streamline the automation of port operations. The proximity of several international container ports allows for automated shipping on routes such as Guangzhou-Shenzhen, Shenzhen-Hong Kong, Malaysia's Tanjung Pelepas-Singapore's Megaport Tuas, and container terminals in the Newark-New York City area. barge operation becomes possible. Traffic conditions near the Port of Newark and New York container terminals are prompting consideration of a future elevated rail container transportation system that would connect container terminals and intermodal rail terminals in close proximity to each other. Significant progress has already been made internationally in autonomous port operations. The automation trend is expected to continue and expand in scope in the future. Self-driving truck developer has suggested that long-haul vehicles carrying containers could be operational by the end of 2021 or early 2022. Despite the current pandemic and the resulting lockdown of entire populations in major cities around the world, the need to move various types of trade internationally remains. Advances in telecommunications and computer technology will provide a platform for autonomous operations at ports, including future ship movements and cargo movement between ships and terminals, and between ships and various land transport modes. Drones deployed in ports and on transport vehicles will contribute to future transport operations by surveying the area ahead and optimizing the efficient movement of transport vehicles (Domenico & Domenica 2023).



Kon., et. al. (2020), opined that port automation has many benefits, but it also comes with its own challenges and considerations. One of the biggest challenges is the high cost of implementing automated systems. The initial investment required to install robotic equipment, sensors, and intelligent systems can be significant, especially for smaller ports or ports with limited resources. In addition, the maintenance and operating costs of these systems can also be significant. Another challenge is the potential impact on employees. Longshoremen are at risk of losing their jobs as more and more tasks become automated. However, it is important to note that port automation does not necessarily lead to job losses. In return, human resources are freed from repetitive, physically taxing tasks and freed up to focus on more complex, value-added activities. Additionally, integrating different technologies into port automation systems can be complex and requires extensive planning and coordination. To ensure smooth operation, the interoperability of various systems and the compatibility of hardware and software components must be carefully checked. Finally, cybersecurity is an important aspect of port automation. As ports become more connected and rely more on digital systems, they are also becoming more vulnerable to cyber threats. To protect port operations from potential cyber-attacks, appropriate security measures such as firewalls, encryption, and regular system audits must be in place. Automation will create new challenges and threats for port labor in the face of increasing demand for new jobs focused on highly qualified talent. This paper shows that the anticipated “strength to skill” transition will require new skills in the workforce and, as a result, will require specific training programs and certifications (Domenico & Domenica 2023). Considering the above situation, the objective of this study is to demonstrate the impact of port automation on vessel traffic in Calabar Port. Therefore, industry stakeholders can leverage the benefits of financial investments in port automation, and the results achieved will add value to the existing literature and encourage government agencies such as NPA, NIMASA, NSC. It will also be useful for stack holders. It will be beneficial to the region's maritime industry and future researchers.

Literature Review

Queuing Theory by Agner Krarup Erlang (1909) was adopted for this study. The performance of ports can be measured using this theory. We must determine the probability attributes connected to the incoming request flow, service discipline, and service time in order to characterize this queuing model. (Janos, 2012). Additionally, the theory suggests that inter-arrival and service delays are occasionally independent random

variables. Furthermore, the theory clarifies how the service's structure and discipline account for the system's capacity, server count, and the maximum number of customers—including underserved ones—that can remain in the system. (Janos, 2012). According to the service discipline guideline, Calabar port is the next customer or vessel. The most widely used regulations are LIFO (last in first out), which states that the person who arrives later leaves first, and FIFO (first in first out), which indicates that the person who arrives first will be served first. The core of queuing theory is to measure the probability properties of the system, which include the density function, distribution function, mean of the variables: number of waiting customers (ships), number of customers in the system, utilization of the servers, customer response time, customer waiting time, idle time of the server, and busy time of the server. Random Service: the customer is assigned a priority and is served randomly (Janos, 2012). Assumptions about the distribution of service time, number of servers, service times, capacity, and service discipline all have a significant impact on the outcome.

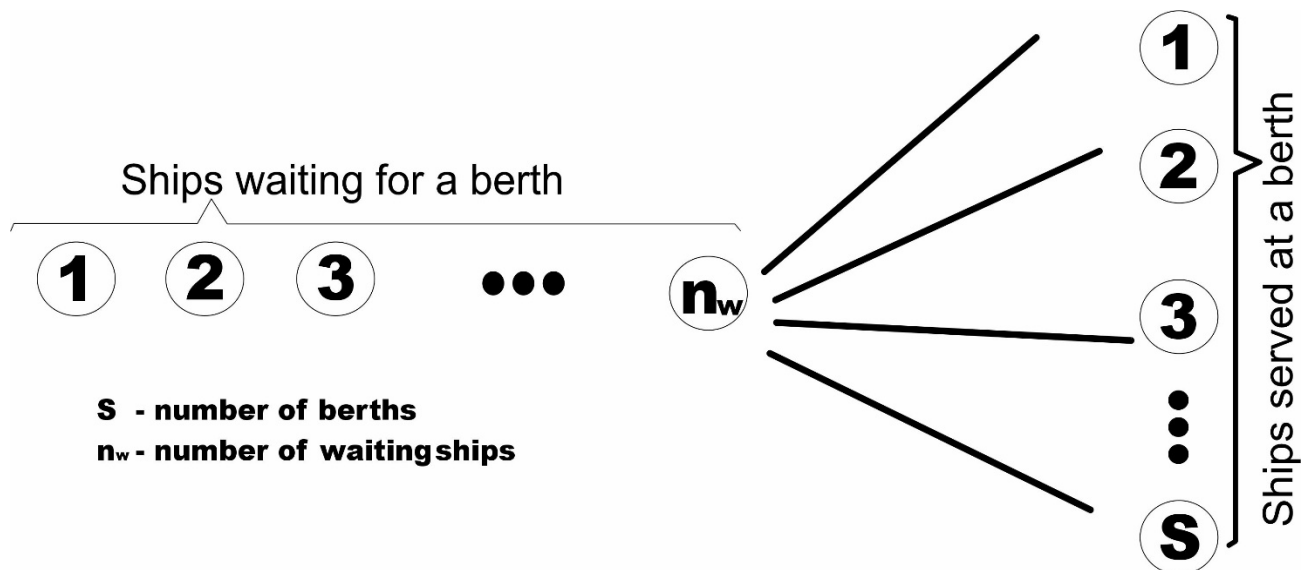


Figure 1: Queuing System of Vessel El-Naggar (2010)

In the absence of opportunities to expand infrastructure, effective planning of vessel traffic in port waters may be required to reduce port congestion. Vessel traffic planning focuses on minimizing vessel delays. A port typically consists of a cargo terminal, an internal berth, an external berth, and a shipping channel, as shown in Figure 2.

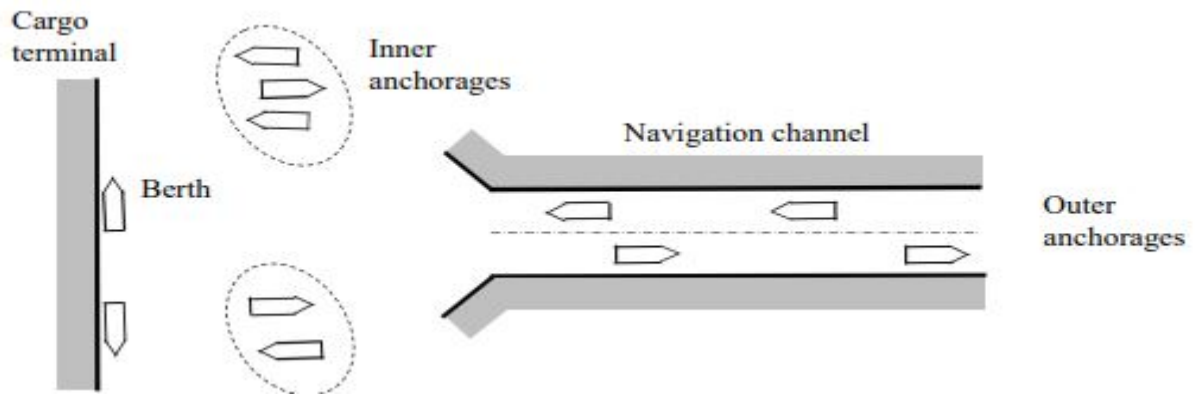


Figure 2: An Illustrative Seaport Layout. Shuai Jia (2022).

When a vessel arrives at a port to load or discharge cargo, it must wait at an external berth before being allowed to approach the cargo terminal. Once access is granted to the cargo terminal, the ship transits the shipping route and arrives at the designated berth at the cargo terminal for service. If a berth is not available after a vessel has passed through the strait, the vessel must wait in an internal berth until it is allowed to berth. After loading cargo at the terminal, the ship leaves the berth, crosses the shipping lane, and finally exits the port from an external berth. If a ship is not granted access to the channel when it completes a cargo discharge, it must proceed to an internal berth and wait for access to the canal. Since the traffic capacity of port facilities (internal berths, shipping lanes, etc.) is limited, port operators need to manage ship traffic within port waters to avoid congestion and allow ships to arrive and depart as planned. Recent studies have shown that advanced planning approaches and automation can significantly improve port traffic management practices and minimize vessel delays Keraleva et al. (2012, 2013). Plan incoming and outgoing ships in a port channel by considering tidal effects. They control ship traffic within the canal by allocating high-tide periods to deep-draft vessels and low-tide periods to shallow-draft vessels. Their method outperforms the standard is FCFS (first-come, first-served) policy in terms of congestion mitigation and increases the channel's traffic throughput. Zhang et al. (2016) also consider safe distance limits in shipping routes, where a safe distance must be maintained between vessels. Liu et al. (2021) proposed an integrated optimization model that jointly makes ship traffic planning and berth planning decisions to minimize ship delays. Vessels must pass through shipping lanes when entering or leaving a port. The fairway consists of two lanes, one for inbound vessels and one for outbound vessels (see Figure 1). Each lane is one-way, so incoming and outgoing vessels must enter the lane one after the other and travel in the lane at the same speed.



Furthermore, since the water depth of the canal varies over time due to tidal effects (Du et al. 2015; Ding et al. 2016), each ship is affected by a series of tidal windows when navigating within the canal. If an incoming vessel has passed through the channel, but the designated berth is not currently available, the vessel must wait in an internal berth until it is allowed to dock. Additionally, if a departing vessel has completed cargo handling but the route is currently unavailable, the vessel must wait in an internal berth until it is cleared to enter and depart the route.

Port operations are changing due to new dynamics shaping today's port environment. From this perspective, there are six main categories of driving factors which are;

1. Increasing port competition
2. Liner shipping strategy (Cariou, 2008)
3. Technology development (Ganesan et al., 2016; Niederman et al., 2007)
4. Commercialization.
5. New organizational models.
6. Expansion of containerization.

These factors are having a significant impact on port operations, which are transitioning in nature from capital-intensive to labor-intensive. Port workers need to respond and adapt to new changes in port conditions. It is argued that the development of port operations is influenced by technology-driven trends. Digitalization and automation (Satta et al., 2019; Cariou, 2018; Fruth and Teuteberg, 2017; Martin-Soberon et al., 2014). Digitalization and automation are valuable foundational technologies shaping the new paradigm of Industry 4.0, or the fourth industrial revolution. This revolution represents a shift from asset operators to service orchestrators, creating more added value for port operators (McKinsey & Co, 2018). In particular, it is based on the introduction of new digital technologies and automation systems to improve general working conditions in sea ports, the quality of strategic planning and business models adopted, communication with stakeholders, and productivity (PwC, 2016). As of mid-2018, 47 container ports around the world are partially or fully automated (Rodrigue, 2018). Recent port automation efforts and projects include NxtPort, an information sharing platform developed by the Port of Antwerp, the Port of Los Angeles' TraPac terminal, and the new Qianwan container terminal at the Port of Qingdao in Asia. This new technology paradigm will facilitate and support the improvement and procedures involved in port operations. In this

regard, it is argued that digitalization improves high levels of port efficiency, safety and energy savings in the seaport context (Cariou, 2018), while automation of port operations leads to higher levels of efficiency, proven to ensure standardization. Productivity and quality in port processes (Martin-Soberon et al., 2014). From this point of view, familiarity with data collection, activity monitoring, track and trace operations and automation systems is considered fundamental for port operations, developing new business models and strengthening the competitiveness of seaports. This will further strengthen the efforts of port operators.

Result and Discussion

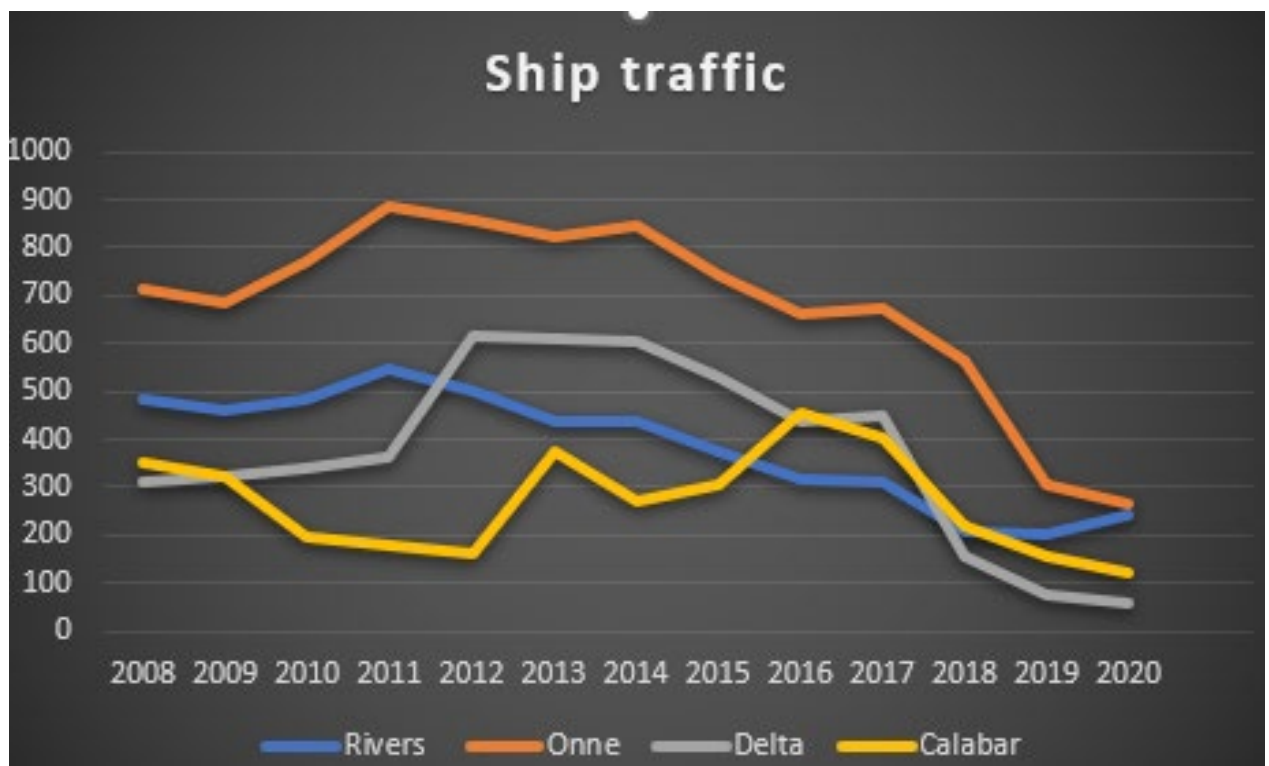


Figure 3: Ship Traffic Pattern for the ports of Delta, Onne, Rivers, and Calabar (NPA, 2021)

The ship traffic pattern for the ports of Delta, Onne, River, and Calabar between 2008 and 2020 is depicted in Figure 3. Ship traffic in Onne Port and River Port increased between 2009 and 2011, then started to decline in 2012. In addition, it went down from 2015 to 2019 and up from 2013 to 2014. Between 2008 and 2014, Delta Port saw an increasing trend; between 2015 and 2020, it saw a decreasing trend. From 2008 to 2012, the trend in Calabar Port decreased; from 2013 to 2016, it increased; and from 2017 to 2020, it decreased again.



Port automation transforms the way cargoes are handled, increasing productivity and streamlining processes. Port automation refers to the use of advanced technologies and robotics to automate various aspects of port operations. These technologies include container handling robots, dry bulk loading and discharging, liquid bulk loading and discharging, automated cranes and smart conveyor systems. By replacing manual labor with automated systems, ports can significantly increase efficiency and reduce the risk of accidents. One of the key elements of port automation is the use of automated guided vehicles (AGVs) to transport containers around the port. These AGVs are equipped with sensors and navigation systems that allow them to navigate ports without human intervention. They can transport cargoes from ship to storage yard or vice versa, ensuring the entire process runs smoothly and efficiently. Another important aspect of port automation is the implementation of smart systems to monitor cargo movements in real time. These systems use sensors and analyze data on the location, condition and status of containers, providing accurate and up-to-date information to port operators and shippers. This allows them to make informed decisions and optimize the flow of goods through the port. Contrary to popular belief, port automation does not completely eliminate the need for human intervention. Instead, it promotes a collaborative approach between humans and machines, where each complements the strengths of the other. While machines perform repetitive, physically demanding tasks, humans provide the critical thinking, creativity and adaptability needed for decision making and complex problem solving. In automated ports, humans play an important role in monitoring and managing the operation of the automated system. They are responsible for monitoring the performance of machines, ensuring that they are operating properly, and resolving any problems that may arise. They also provide the expertise and knowledge needed to make strategic decisions and optimize the port's overall performance. Port automation has a significant impact on port operational efficiency and productivity. By replacing manual labor with automated systems, ports can achieve higher output, reduce operating costs and improve overall performance. In addition to efficiency and productivity benefits, port automation also promotes sustainability and environmental responsibility through the use of green technology. Automated ports are at the forefront of adopting environmentally friendly measures and technologies to minimize carbon emissions and reduce environmental impact. One of the important green technologies in automated ports is the use of electrical equipment. By replacing diesel-powered machinery with electric alternatives, docks can

significantly reduce air and noise pollution levels. Electric cranes, AGVs and other equipment produce no emissions at the time of use, making them a cleaner, quieter alternative. Another green technology in automated ports is the integration of renewable energy sources. Ports are exploring the use of solar panels, wind turbines and other renewable energy systems to power their operations. These energy sources can help reduce dependence on fossil fuels, reduce greenhouse gas emissions and contribute to more sustainable energy sources.

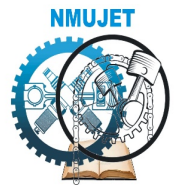
Conclusion

We can critically deduce that Port Automation do impact on vessel traffic, where by an automated port will increase cargo throughput and reduce vessel turnaround time in port. Furthermore, automated ports had the least turnaround time during the Covid-19 pandemic, particularly in the eastern ports of Nigeria. Where vessels stay more than required to either load or discharge in port, thereby causing port congestion. Port automation is transforming the maritime industry, including how goods are handled and port operations streamlined. By using advanced technology and robotics, ports can increase efficiency, reduce risk and optimize the flow of goods. Port automation presents challenges in terms of cost, labor, integration, and cybersecurity, but these can be carefully addressed and managed. Port automation fosters a collaborative approach between humans and machines, complementing the strengths of each.

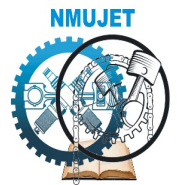
Increase efficiency and productivity by reducing human error, optimizing resource utilization, and increasing security. Furthermore, port automation promotes sustainability and environmental responsibility through the use of green technologies. Electric equipment, renewable energy sources and energy optimization measures contribute to a cleaner and more sustainable maritime industry. In summary, the world of port automation is transforming global supply chains and presenting exciting opportunities for shippers, port operators, and everyone interested in the future of logistics.

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