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# The Impact of Automation of Operational Processes and Its Role in Raising the Competitiveness of the Aden Container Terminal

[1] Aref Hasan Abdullah Al-shabi and
[2] Osama Fawzy Ahmed Elbayoumi

[1] Aden Port Development Company, Port of Aden.
[2] Arab Academy for Science, Technology and Maritime Transport (AASTMT)

Emails: aref.alshabi1974@gmail.com , osamaelbayoumi@egypt.aast.edu

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## ABSTRACT

***Purpose:*** *Ports are an essential pillar of economic development globally, as they contribute significantly to enhancing local and international trade exchange. Ports seek to improve their efficiency and provide high-quality services to meet customer needs. Consequently, many countries have developed their maritime capabilities using ICT, which has increased trade volume, reduced overall costs, and reduced port arrival time for ships. Since its emergence, container transportation has become vital in the field of logistics and global trade, as it contributes significantly to improving the efficiency of supply chains by simplifying shipping and tracking processes using modern technology, and effectively enhances local and international trade exchange.*

*The study aims to investigate the impact of automation of operational processes on the competitiveness of the Aden Container Terminal, and to provide future directions and suggestions for enhancing competitiveness through the application of technology and automation.*

***Approach/Design/Methodology:*** *The researcher used the descriptive analytical approach, where a questionnaire was created to measure the impact of automation of operational processes at the Aden Container Terminal, and this data was analyzed using the SPSS program.*

**Key-words:**
*Automation, Operational Processes, Competitiveness, Aden Container Terminal, Yemen.*

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## INTRODUCTION

The globalization of the world economy has increased the role and importance of the maritime transport industry, particularly container transport. Maritime transport is the backbone of international trade and the global economy, with over 80 percent of global trade volume transported by sea worldwide. The United Nations Conference on Trade and Development (UNCTAD) estimated the total volume of maritime trade in 2019 at 11.08 billion tons (UNCTAD 2023).

Ports are a fundamental pillar and a vital supporter of economic development worldwide. They play a prominent role in enhancing trade exchange on both national and international levels. Ports have focused on improving efficiency and enhancing the quality of services provided to meet the needs of current and future customers. Many countries have made serious efforts to improve their maritime performance using Information and Communication Technology (ICT), leading to increased overall trade volume, reduced total costs, and reduced ship stay times at ports. Since its inception, container transportation has become a fundamental pillar in logistics and global trade, playing an undeniable role in improving the effectiveness and efficiency of supply chains. Container transportation enhances logistics operations by simplifying shipping and tracking processes using modern technology and effectively facilitates trade exchange on both national and international levels.

In modern shipping, port automation has become essential. It enhances efficiency and accuracy in loading and unloading operations, helps reduce delays and congestion at ports, and improves time and resource management by enabling continuous and efficient operations. Additionally, port automation improves cargo tracking and inventory management, reducing cargo losses and increasing transparency in transportation operations. Automation also contributes to providing better logistics services to customers and increasing their overall satisfaction.

### Significance of the Study

The importance of studying automation lies in its significant contribution to enhancing the effectiveness and efficiency of logistics operations at ports, improving their performance, and transforming them into effective and safe work environments. Automation speeds up loading and unloading operations using smart equipment and robots, reducing waiting times and increasing port productivity.

This, in turn, improves customer experience and enhances port competitiveness. Thus, automation enhances efficiency and reduces costs at the port. This study analyzes the opportunities and challenges of applying automation at the Aden Container Terminal, a topic that has not been previously addressed, to derive conclusions about the expected impacts on the terminal's competitiveness.

### Statement of the Problem

Regional and neighboring container terminals to the Aden Container Terminal have seen significant development in their use of port technology, increasing their competitiveness. Despite the unique location of the Aden Container Terminal, the lack of necessary actions to develop it has negatively impacted its performance and reduced its operational efficiency and competitiveness. This has prevented the terminal from keeping pace with surrounding developments, while neighboring ports have increased their competitiveness. Additionally, lack of automation in various sections of the port poses a significant issue for the shipping industry and cargo management at the terminal. Hence, the question of the study arises: How can automation contribute to increasing the competitiveness of the Aden Container Terminal?

### Objectives of the Study

The study aims to investigate the impact of automation of operational processes on the competitiveness of the Aden Container Terminal. Research objectives are:

- To identify the deficiencies and weaknesses that have affected the competitiveness of the Aden Container Terminal.
- To propose future visions and suggestions for applying automation and its role in enhancing the terminal's competitiveness.

### Study variables

Study variables refer to the factors or elements that are being measured, manipulated, or observed in a research study or experiment. These variables can be classified into two main types:

- Independent Variables: These are the variables that the researcher intentionally manipulates or controls to observe their effect on other variables. Independent variables are also known as predictor variables or causal variables.
- Dependent Variables: These are the variables that are observed, measured, or recorded as outcomes in response to changes in the independent variables. Dependent variables

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are also known as outcome variables or response variables.

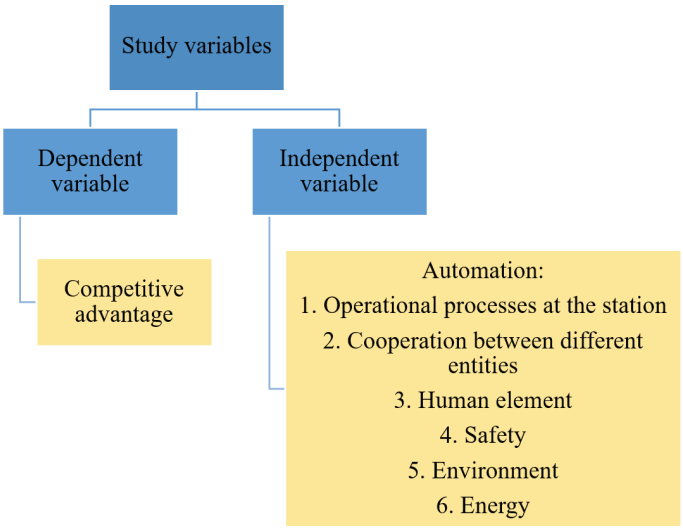


Fig. 1. Study variables (Source: The researcher)

## Hypotheses of the Study

**H1:** There is a positive relationship between automation and the competitiveness of the Aden Container Terminal, branching into the following sub-hypotheses:

**H 1-1:** There is a positive relationship between operational processes and the competitiveness of the Aden Container Terminal.
**H 1-2:** There is a positive relationship between automation (cooperation between different entities) and the competitiveness of the Aden Container Terminal.
**H 1-3:** There is a positive relationship between human element and the competitiveness of the Aden Container Terminal.
**H 1-4:** There is a positive relationship between security and the competitiveness of the Aden Container Terminal.
**H 1-5:** There is a positive relationship between environment and the competitiveness of the Aden Container Terminal.
**H 1-6:** There is a positive relationship between energy and the competitiveness of the Aden Container Terminal.

## METHODOLGY OF THE STUDY

The researcher used the descriptive analytical approach, combining both quantitative and qualitative methods. As the researcher works at the Aden Container Terminal, he is directly involved with the reasons for not adopting modern systems (automation) implemented in most modern seaports. A questionnaire was created to measure the impact of automation of operational processes at the Aden Container Terminal, and these data were analyzed using the SPSS program. Additionally, an analysis of the internal and external environment of the Aden Container Terminal (SWOT analysis) is conducted to identify strengths, weaknesses, opportunities, and threats.

## Study Limits

- The research aims to study the Aden Container Terminal, which is part of the Port of Aden, the main port of Yemen and one of the largest natural ports in the world and the primary ports in the Gulf of Aden and the Red Sea (Qurdash, 2021).
- The study focuses on data and comparisons over five years, from 2019 to 2023.

## LITERATURE REVIEW

Siyouh et al. (2017) highlighted the importance of maritime transport for the economy and Syrian ports. It aimed to understand the impact of electronic applications on the operation of Syrian ports by sending data electronically without human intervention, applied to the Port of Latakia. The researchers concluded that there is a good environment for using technological applications, the possibility of applying electronic data transmission, and the possibility of implementing VTS systems in the Port of Latakia. They recommended that the government reviews and amends legal systems to align with electronic business practices and international standards.

Gerlitz and Meyer (2021) aimed to address the limited administrative capacity of small and medium-sized ports in the European Union in terms of environmental responsibility and digital efficiency. It sought to bridge the gap between research and practice by improving decision-making capacity for small and medium-sized port service providers in pursuing sustainable and digital port services. The study recommended improving the limited administrative capacity of small and medium service providers regarding environmental responsibility and digital efficiency using proposed decision-making tools.

Heilig et al. (2017) analyzed digital transformations in seaports and their impact on port operations. It aimed to provide a comprehensive overview of seaport development, focusing on digital transformation, and to identify and explain the significant impacts of digital transformation, particularly in relation to smart ports. The study mentioned that digital transformation has a

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significant impact on port operations in terms of costs, efficiency, security, and sustainability, with terminal equipment integration enabling automation, leading to improved productivity and competitiveness.

Yang et al. (2018): This study compared traditional container terminals with automated container terminals using modern technology. It provided the following comparison as shown in Table 1:

Table 1: Comparison between Traditional Container Terminals and Automated Container Terminals.

| Characteristics | Traditional Container Terminal | Automated Container Terminal |
|---|---|---|
| Operation | Workers and machines | Automated systems and equipment |
| Operations on the quay | Quay cranes | Semi-automatic/automatic quay cranes |
| Horizontal transport | Container trucks and extended carriers | Container trucks, extended carriers, AGVs |
| Container yard operations | Rubber-tyred gantry cranes | Automated rail-mounted gantry cranes |
| Operational efficiency | Labor-dependent, limited efficiency | Information-based, high efficiency |
| Economic efficiency | Low construction and maintenance costs, high labor and transport costs | High construction and maintenance costs, low labor and transport costs |
| Supervision and security control | Low reliability, slow response | High intelligence, high reliability, quick response, more secure |
| Environmental protection | High energy consumption, heavy pollution | Low energy usage, minimal pollution |
| Sustainability | No | Yes |

Source: Yang et al. (2018)

Douaioui et al. (2018): This research aimed to define the concept of logistics intelligence and identify the main challenges that led researchers to consider the smart port. The study proposed a model for the smart port concept by identifying its core pillars and the essential components for the success of each pillar. Technology and innovation, the environmental dimension, operational excellence, security, and governance were among the core pillars identified by the study.

Schröder et al. (2017): This study explored the development of Industry 4.0 in logistics and its impact on port operations. It aimed to provide a comprehensive overview of Industry 4.0 development and to explain significant impacts on port operations. The study concluded that Industry 4.0 has a significant impact on port operations, particularly in terms of costs, efficiency, security, and sustainability. It recommended the integration of terminal equipment to enable automation and improve productivity and competitiveness.

The study of Meyer et al. (2021) aimed to investigate the impact of digital and environmental twinning perspective on assessing the readiness of small and medium-sized ports for sustainable development in the Baltic Sea region. The research relied on audit processes conducted in small and medium-sized ports in the Baltic Sea region. In total, 38 ports participated in the audit processes during the period from 2014 to 2020, which were conducted as organized interviews or through online surveys using a measurement model. The results revealed significant challenges facing small and medium-sized ports in this region, particularly lack of financial support from European financing programs. The results also highlighted the importance of these ports in promoting economic development at the regional level, acting as gateways to individual areas, and contributing to social, economic, and environmental transformation. Additionally, the results indicated that ports play a vital role in tracking innovation paths in port management and adapting to environmental goals set by the European Commission for the maritime sector for the periods 2030 and 2050. This responds to the challenges of innovation and development, enabling successful digital and environmental transformation in small and medium-sized ports. Therefore, it emphasizes the importance of assessing sustainable readiness to implement customized solutions based on individual needs and ensuring the effective use of available resources and capacities.

Digitization impacts all areas of maritime transport and logistics. The ability of ports to function as part of digital networks and information chains is crucial for their competitiveness. Hence, a study by Brunila et al. (2021) aimed to identify the challenges facing the adoption of digital technologies in the port sector, focusing on analyzing the problems and possible solutions. The study showed that the impact of digital technologies extends to all aspects of maritime transport and logistics services. The results emphasized the importance of the ability of ports to integrate into digital networks and information chains, which is essential for enhancing their competitiveness. To achieve this, the necessary requirements and infrastructure must be available for integration with modern technology platforms in various port operations. The results confirmed that the success of digital upgrade operations depends on advanced technological management, ensuring smooth interaction between systems and data transfer.

The study highlights the importance of evaluating the readiness of port operations to face these technological challenges and achieve sustainability and efficiency in adopting digital technologies.

The study of Elbayoumi (2022) aimed to measure the operational efficiency of the most important container terminals in the Middle East, which had the highest productivity in 2020. The study also aimed to measure the impact of operational efficiency on the competitiveness of container terminals in the Middle East region. The study recommended that Egyptian container terminals increase their productivity: Sokhna by 13%, Damietta by 30%, and Alexandria by 50%.

Qureshi (2021) discussed the current capacity of the Aden Container Terminal in light of the accelerating stages of service and technological progress of container terminals in the region, especially given the conflicting geopolitical interests in the Red Sea region. The research was classified as descriptive and quantitative analysis through comparisons, data collection, and analysis. The research was conducted by addressing previous studies that focused on the competitiveness of container terminals. The second stage involved analyzing the market structure by presenting and analyzing the competitive capacities of competing terminals in the region and evaluating the capacity of the Aden Container Terminal and competing terminals using HHI and CRN indices to determine competitive levels and monopolistic ratios among container terminals located in the specified geographic area in the research. In the third stage, the competitiveness of the Aden Container Terminal was analyzed using a SWOT analysis matrix.

Abdo et al. (2022) aimed to develop a proposal using the hierarchical analysis model to increase the competitiveness of the Aden Container Terminal during 2021. The hierarchical analysis model determines the relative importance of the variables used to determine the competitiveness of container terminals. The study found deficiencies and weaknesses in all selected variables to measure competitiveness, including waterway depth, storage area, quay length, and handling equipment. According to the hierarchical analysis model, it was found that the Aden Container Terminal suffers from a very poor performance level in all variables used. To enhance the competitiveness of the terminal, investments must be made in all variables under study, transforming them from very poor to good or very good performance levels. The study also showed that the Salalah Container Terminal ranked first in competitiveness among the studied container terminals, while the Djibouti Container Terminal ranked second.

## Statistical Analysis

The study population consists of employees from various specialties at the Aden Container Terminal, totaling 1500 individuals. The study employed a stratified random sampling method. Therefore, a stratified random sample was selected from the employees at the Aden Container Terminal. The sample size was determined from the study population using the following equation:

$$n = \frac{N \times p(1-p)}{N-1 \times (d^2 \div z^2) + p(1-p)}$$

Where:
- \( N \) = Population size
- \( n \) = Sample size
- \( z \) = Standard score corresponding to a 95% confidence level, which is 1.96
- \( d \) = Margin of error, which is 0.05
- \( p \) = Maximum proportion of the desired characteristics available in the study population, which is 0.50

The calculation of the required study sample size can be distributed across the study population compensatory in the preceding equation as follows:

$$n = \frac{1500 \times 0.5(1-0.5)}{1500-1 \times (0.05)^2 \div (1.96)^2 + 0.5(1-0.5)}$$

$$n = \frac{1500 \times 0.25}{1499 \times (0.0025) \div (3.8416) + 0.25}$$

$$n = \frac{375}{1499 \times (0.000650771) + 0.25}$$

$$n = \frac{375}{1.225504998}$$

$$n = 305.9963$$

Through substituting the values into the preceding equation, it becomes evident that the required sample size for the study distributed across the study population amounted to 306 individuals. Table 2 illustrates the distribution of the study sample across different categories of the study population, according to the representation of the proportion of each category in the study population.

The researcher relied on the stratified random sampling method from the study population at Aden Container Terminal, the study site, as the study population is heterogeneous, comprising a diverse group of workers with varying specialties, qualifications, and job titles, along with differences in their numbers at different administrative levels.

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The researcher distributed the survey questionnaires to the different categories within the study site, and they were responded to by individuals in the sample with varying response rates. Table 2 illustrates the study population, sample, distributed questionnaires, retrieved questionnaires, and excluded questionnaires for all individuals in the study sample.

Table 2: The Distributed, Retrieved, and Excluded Questionnaires along with the Response Rate

| Study Community | Sample Size | Distributed Surveys | Returned Surveys | Excluded Surveys | Response Rate |
|---|---|---|---|---|---|
| 1500 | 306 | 306 | 282 | 24 | 92.16% |

Source: The author

## DESCRIPTIVE STATISTICS RESULTS

### Analysis of Operational Process Automation Dimensions

#### Analysis of items after operational processes:

Table 3: Average, Standard Deviation, and Relative Importance of Items after Operational Processes

| N. | Statement | Average | S. D. | Relative Importance | Ranking |
|---|---|---|---|---|---|
| 1 | Automating operations at the Aden Container Terminal will contribute to improving operational efficiency. | 3.12 | 0.628 | 62.48% | 3 |
| 2 | Automating operations at the terminal will lead to a reduction in the time required to process containers. | 3.47 | 0.827 | 69.36% | 1 |
| 3 | The presence of a robust automation system at the terminal enhances the attractiveness of the port to logistics companies and shipping firms. | 2.84 | 0.809 | 56.81% | 5 |
| 4 | Automating operations at the Aden Container Terminal will enhance the competitiveness of the station in the maritime shipping market. | 3.24 | 0.588 | 64.75% | 2 |
| 5 | The presence of a strong automation system will lead to accuracy or error reduction. | 3.03 | 0.581 | 60.64% | 4 |
| | **Average** | 3.14 | 0.451 | 62.81% | |

Source: The author

Data from table 3 indicate that the overall score of the sample individuals' responses to the items related to operational automation was moderate, with an arithmetic mean of 3.14 and a standard deviation of 0.451. The highest responses from the sample individuals were for the item stating, "Automation of operations at the terminal will reduce the time required to process containers," while the lowest responses from the sample individuals were for the item stating, "The presence of a strong automation system at the terminal enhances the attractiveness of the port to logistics companies and shipping companies."

### Analysis of items of collaboration between different entities:

Table 4: Average, Standard Deviation, and Relative Importance of Items after Collaboration between Different Entities

| N. | Statement | Average | S. D. | Relative Importance | Ranking |
|---|---|---|---|---|---|
| 1 | Automating operations at the Aden Container Terminal will contribute to improving collaboration among different entities. | 3.41 | 0.751 | 68.30% | 2 |
| 2 | There will be an improvement in communication between different departments at the terminal due to the automation of operations. | 3.72 | 0.816 | 74.33% | 1 |
| 3 | Automating operations will facilitate operations and interaction between different entities. | 3.14 | 0.717 | 62.84% | 4 |
| 4 | Automating operations will contribute to increasing the transparency of operations among different entities. | 2.79 | 0.818 | 55.89% | 5 |
| 5 | Automating operations at the terminal will lead to improving the quality of service provided to customers. | 3.29 | 0.674 | 65.74% | 3 |
| | **Average** | 3.27 | 0.491 | 65.42% | |

Source: The author

Data from table 4 indicate that the overall score of the sample individuals' responses to the items related to collaboration among different entities was moderate, with an arithmetic mean of 3.27 and a standard deviation of 0.491. The highest responses from the sample individuals were for the item stating,

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"There will be an improvement in communication between different departments at the terminal due to operational automation," while the lowest responses from the sample individuals were for the item stating, "Operational automation will contribute to increasing transparency of operations among different entities."

## Analysis of items of human element:

Table 5: Average, Standard Deviation, and Relative Importance of Items after the Human Element

| N. | Statement | Average | S. D. | Relative Importance | Ranking |
|---|---|---|---|---|---|
| 1 | Automating operations at the terminal will contribute to improving the working environment for employees. | 3.35 | 0.676 | 67.09% | 2 |
| 2 | Automating operations will lead to reducing operational pressure on employees at the terminal. | 3.06 | 0.662 | 61.13% | 4 |
| 3 | Automating operations at the terminal will contribute to reducing the risk of accidents resulting from human errors. | 3.58 | 0.784 | 71.56% | 1 |
| 4 | Automating operations will lead to improving interaction between employees and management. | 3.18 | 0.707 | 63.69% | 3 |
| 5 | Adopting modern technology in automating operations will contribute to enhancing employees' skills and capabilities. | 2.88 | 0.843 | 57.59% | 5 |
| | **Average** | 3.31 | 0.609 | 66.21% | |

Source: The author

Data from table 5 indicate that the overall score of the sample individuals' responses to the items related to the human element dimension was moderate, with an arithmetic mean of 3.31 and a standard deviation of 0.609. The highest responses from the sample individuals were for the item stating, "Operational automation at the terminal will contribute to reducing the risk of accidents resulting from human errors," while the lowest responses from the sample individuals were for the item stating, "Adopting modern technology in operational automation will contribute to improving the skills and capabilities of employees."

## Analysis of items of safety:

Table 6: Average, Standard Deviation, and Relative Importance of Items after Safety

| N. | Statement | Average | S. D. | Relative Importance | Ranking |
|---|---|---|---|---|---|
| 1 | Employees at the terminal believe that there is a need to increase security awareness regarding technology and process automation. | 3.33 | 0.769 | 66.60% | 3 |
| 2 | Workplace accidents or collisions are expected to decrease due to the automation of operations at the terminal. | 3.17 | 0.746 | 63.48% | 4 |
| 3 | Automating operations may improve understanding and implementation of safety procedures at the terminal. | 2.93 | 0.836 | 58.58% | 5 |
| 4 | Automating operations at the Aden Container Terminal will contribute to improving overall safety levels at the terminal. | 3.45 | 0.786 | 69.01% | 2 |
| 5 | There are challenges in improving safety levels during the implementation of operation automation at the terminal. | 3.67 | 0.849 | 73.40% | 1 |
| | **Average** | 3.21 | 0.419 | 64.21% | |

Source: The author

Data from table 6 indicate that the overall score of the sample individuals' responses to the items related to the safety dimension was moderate, with an arithmetic mean of 3.21 and a standard deviation of 0.726. The highest responses from the sample individuals were for the item stating, "There are challenges in improving safety levels during the implementation of operational automation at the terminal," while the lowest responses from the sample individuals were for the item stating, "Operational automation may improve the understanding and implementation of safety procedures at the terminal."

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## Analysis of items of environment:

Table 7: Mean, Standard Deviation, and Relative Importance of Items after Environment

| N. | Statement | Aver-age | S. D. | Relative Importance | Ranking |
|---|---|---|---|---|---|
| 1 | There is a need for additional investments to improve the environmental impact of station operations. | 3.51 | 0.801 | 70.28% | 1 |
| 2 | Automating operations at the Aden Container Terminal will contribute to enhancing the environmental efficiency of operations. | 3.23 | 0.705 | 64.54% | 3 |
| 3 | Improvements in waste management and environmental impact reduction will occur due to the automation of operations. | 2.96 | 0.744 | 59.29% | 5 |
| 4 | Automating operations will contribute to reducing environmental emissions and improving air quality in the vicinity of the terminal. | 3.18 | 0.714 | 63.55% | 4 |
| 5 | There are challenges in improving the environmental impact during the implementation process of operation automation at the terminal. | 3.37 | 0.725 | 67.38% | 2 |
| | **Average** | 3.25 | 0.489 | 65.01% | |

Source: the author

Data from table 7 indicate that the overall score of the sample individuals' responses to the items related to the environmental dimension was moderate, with an arithmetic mean of 3.25 and a standard deviation of 0.489. The highest responses from the sample individuals were for the item stating, "There is a need for additional investments to improve the environmental impact of the terminal's operations," while the lowest responses from the sample individuals were for the item stating, "There will be an improvement in waste management and a reduction in environmental impact due to operational automation."

## Analysis of items of energy:

Table 8: Mean, Standard Deviation, and Relative Importance of Items after Energy

| Ranking | Relative Importance | S. D. | Aver-age | Statement | N. |
|---|---|---|---|---|---|
| 4 | 61.28% | 0.775 | 3.06 | Operational automation at the Aden Container Terminal will contribute to reducing energy consumption for operational processes. | 1 |
| 3 | 62.77% | 0.772 | 3.14 | Operational automation will enhance the sustainability of energy use at the container terminal. | 2 |
| 5 | 58.44% | 0.857 | 2.92 | Automation will increase the use of more efficient energy sources at the terminal. | 3 |
| 2 | 64.96% | 0.765 | 3.25 | There is a need to improve integration between operational automation systems and energy management. | 4 |
| 1 | 68.58% | 0.863 | 3.43 | There are challenges in improving the sustainability of energy use during the implementation of operational automation at the terminal. | 5 |
| | 63.21% | 0.661 | 3.16 | **Average** | |

Source: The author

Data from table 8 indicate that the overall score of the sample individuals' responses to the items related to the energy dimension was moderate, with an arithmetic mean of 3.16 and a standard deviation of 0.661. The highest responses from the sample individuals were for the item stating, "There are challenges in improving the sustainability of energy use during the implementation of operational automation at the terminal," while the lowest responses from the sample individuals were for the item stating, "Automation will increase the use of more efficient energy sources at the terminal."

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## Analysis of items of competitiveness:

Table 9: Mean, Standard Deviation, and Relative Importance of Items after Competitiveness

| N. | Statement | Aver-age | S. D. | Relative Importance | Ranking |
|---|---|---|---|---|---|
| 1 | Operational automation contributes to reducing waiting times for ships at the Aden Container Terminal. | 3.43 | 0.683 | 68.65% | 3 |
| 2 | Automation improves the accuracy and quality of operations at the Aden Container Terminal. | 3.36 | 0.698 | 67.16% | 4 |
| 3 | Operational automation increases the efficiency of resource utilization at the Aden Container Terminal. | 2.86 | 0.808 | 57.23% | 10 |
| 4 | Automation helps in reducing operational errors at the terminal. | 2.96 | 0.784 | 59.22% | 9 |
| 5 | Automation provides accurate and real-time information to aid in managerial decision-making. | 3.07 | 0.777 | 61.35% | 8 |
| 6 | Improving automation makes the Aden Container Terminal more competitive compared to other terminals in the region. | 3.57 | 0.816 | 71.35% | 2 |
| 7 | Investing in automation technology is economically viable for the Aden Container Terminal. | 3.15 | 0.756 | 63.05% | 7 |
| 8 | Automation helps in enhancing safety and security at the terminal. | 3.29 | 0.717 | 65.89% | 5 |
| 9 | Automation contributes to improving customer satisfaction. | 3.85 | 0.875 | 77.09% | 1 |
| 10 | Automation enhances the capacity of the Aden Container Terminal to handle the increasing volume of containers. | 3.23 | 0.664 | 64.61% | 6 |
| | **Average** | 3.28 | 0.429 | 65.56% | |

Source: The author

Data from table 9 indicate that the overall score of the sample individuals' responses to the items related to the competitiveness dimension was moderate, with an arithmetic mean of 3.28 and a standard deviation of 0.429. The highest responses from the sample individuals were for the item stating, "Automation contributes to improving customer satisfaction," while the lowest responses from the sample individuals were for the item stating, "Operational automation increases the efficiency of resource utilization at the Port of Aden Container Terminal."

## Hypotheses Testing

The main hypothesis of the study states that: There is a positive relationship between the automation of operational processes and the competitiveness of the Aden Container Terminal. This hypothesis has been divided into the following sub-hypotheses:

First sub-hypothesis: There is a positive relationship between operational processes and the competitiveness of the Aden Container Terminal.
To test this hypothesis, the researcher conducted several tests as follows:

## Correlation coefficient

Table 10 illustrates the correlation coefficient between operational processes as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 10: Correlation Coefficient for Sub-Hypothesis One

| Variable | Test | The competitive capability of the Aden Container Terminal |
|---|---|---|
| Operational processes | Correlation coefficient | 0.724 |
| | Significance | 0.000 |

Source: The author

Table 10 indicates a statistically significant correlation of 72.4% at a significance level of 0.05 between operational processes and the competitive capability of the Aden Container Terminal.

## Coefficient of determination

Table 11: Coefficient of Determination for Sub-Hypothesis One

| Independent variable | Coefficient of determination | Adjusted coefficient of determination | Standard error |
|---|---|---|---|
| Operational processes | 0.525 | 0.523 | 0.2967 |

Source: The author

Table 11 indicates that the coefficient of determination ($R^2 = 0.525$), which means that operational processes explain 52.5% of the variation in the competitive capability of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression model, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

## Analysis of variance (ANOVA) test

Table 12: Analysis of Variance for Sub-Hypothesis One

| Title | Sum of squares | Degrees of freedom | Mean square | F | Signifi-cance |
|---|---|---|---|---|---|
| Regression | 27.232 | 1 | 27.232 | 309.32 | 0.000 |
| Residuals | 24.651 | 280 | 0.088 | | |
| Total | 51.884 | 281 | | | |

Source: The author

Table 12 indicates a significant positive correlation between operational processes and the competitive capability of the Aden Container Terminal. This is evident from the \( F \) value, which is statistically significant at the 0.05 level. This signifies the validity and importance of the relationship between the variables and underscores the reliability of relying on the results without errors.

## Regression analysis

Table 13: Regression Results Analysis for Sub-Hypothesis One

| Model | Non-standardized Coefficients | | Standardized Coefficients | t-Test | Signif-icance |
|---|---|---|---|---|---|
| | Beta | Standard Error | Beta | | |
| Constant | 1.106 | 0.125 | 0.724 | 8.863 | 0.000 |
| Operational processes | 0.692 | 0.039 | | 17.587 | 0.000 |

Source: The author

Table 13 shows that the values of the "t-test" for the variable of the operational processes are statistically significant at a significance level of 0.05. This indicates the strength of the regression relationship between operational processes and the competitiveness of the Aden Container Terminal.

From the preceding tables, one can infer the following:

- The significance level of both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between operational processes and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient suggests a positive linear relationship between operational processes and the competitiveness of the Aden Container Terminal.
- The significance level of the overall regression equation (F-test) was less than 0.05, indicating the reliability of the estimated regression model and the possibility of generalizing the sample results to the study population.
- The beta coefficients indicate that operational processes influence the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation is unlikely to be due to chance.
- Based on the above, the researcher can accept the hypothesis that there is a positive relationship between operational processes and the competitiveness of the Aden Container Terminal.

The second sub-hypothesis states: There is a positive relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

## Correlation coefficient:

Table 14 illustrates the correlation coefficient between collaboration among different entities as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 14: Correlation Coefficients for Sub-Hypothesis Two

| Variable | Test | The competitive capability of the Aden Container Terminal |
|---|---|---|
| Collaboration among different entities | Correlation coefficient | 0.809 |
| | Significance | 0.000 |

Source: The author

From table 14, it is evident that there is a statistically significant correlation of 80.9% at a significance level of 0.05 between collaboration among different entities and the competitiveness of the Aden Container Terminal.

## Coefficient of determination

Table 15: Coefficient of Determination for Sub-Hypothesis Two

| Independent variable | Coefficient of determination | Adjusted coefficient of determination | Standard error |
|---|---|---|---|
| Collaboration among different entities | 0.654 | 0.653 | 0.2531 |

Source: The author

Table 15 shows that the coefficient of determination (R^2 = 0.654), indicating that collaboration among different entities explains 65.4% of the variability in the competitiveness of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression relationship, in addition to random errors resulting from sampling

methods, measurement accuracy, and other factors.

## The analysis of variance (ANOVA) test

Table 16: Analysis of Variance for Sub-Hypothesis Two

| Title | Sum of squares | Degrees of freedom | Mean square | F | Signifi-cance |
|---|---|---|---|---|---|
| Regression | 33.953 | 1 | 33.953 | 530.22 | 0.000 |
| Residuals | 17.93 | 280 | 0.064 | | |
| Total | 51.884 | 281 | | | |

Source: The author

From table 16, it is evident that there is a statistically significant positive correlation between collaboration among different entities and the competitiveness of the Aden Container Terminal. This is demonstrated by the F-value, which is statistically significant at a significance level of 0.05. This indicates the validity and substance of the relationship between the variables, ensuring the quality of the framework and the reliability of the results without errors.

## Regression analysis:

Table 17:Regression Results Analysis for Sub-Hypothesis Tw.

| Model | | Non-standardized Coefficients | | Stan-dardized Coeffi-cients | t-Test | Signifi-cance |
|---|---|---|---|---|---|---|
| | | Beta | Standard Error | Beta | | |
| 1 | Constant | 0.958 | 0.102 | 0.809 | 9.397 | 0.000 |
| | Collabora-tion among different entities | 0.709 | 0.031 | | 23.026 | 0.000 |

Source: The author

From table 17, it is evident that the t-test values for the variable of collaboration among different entities are statistically significant at a significance level of 0.05. This indicates the strength of the regression relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal.

From the preceding tables, one can conclude the following:

- The significance level of both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient suggests a positive linear relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal.
- The significance level of the overall regression equation (F-test) was less than 0.05, indicating the reliability of the estimated regression model and the possibility of generalizing the sample results to the study population.
- The beta coefficients indicate that collaboration among different entities influences the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation is unlikely to be due to chance.
- Based on the above, the researcher can accept the hypothesis that there is a positive relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal.

The third sub-hypothesis states: There is a positive relationship between the human element and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

## Correlation coefficient:

Table 18 illustrates the correlation coefficient between the human element as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 18: Correlation Coefficients for Sub-Hypothesis Three

| Variable | Test | The competitive capability of the Aden Container Terminal |
|---|---|---|
| Human element | Correlation coefficient | 0.821 |
| | Significance | 0.000 |

Source: the author

From table 18, it is evident that there is a statistically significant correlation of 82.1% at a significance level of 0.05 between the environment and the competitiveness of the Aden Container Terminal.

## Coefficient of determination

Table 19: Coefficient of Determination for Sub-Hypothesis Three

| Independent variable | Coefficient of determination | Adjusted coefficient of determination | Standard error |
|---|---|---|---|
| Human element | 0.674 | 0.673 | 0.2458 |

Source: The author

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Table 19 indicates that the coefficient of determination (R^2 = 0.783), which means that the human element explains 78.3% of the variation in the competitive capacity of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression equation, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

## The analysis of variance (ANOVA) test

Table 20: Analysis of Variance for Sub-Hypothesis Three

| Title | Sum of squares | Degrees of freedom | Mean square | F | Signifi-cance |
|---|---|---|---|---|---|
| Regression | 34.963 | 1 | 34.963 | 578.57 | 0.000 |
| Residuals | 16.92 | 280 | 0.06 | | |
| Total | 51.884 | 281 | | | |

Source: The author

Table 20 indicates a statistically significant negative correlation between the human element and the competitive capacity of the Aden Container Terminal, as shown by the F-value. This statistical significance at the 0.05 level confirms the validity and substantiality of the relationship between the variables, ensuring the reliability of relying on the results without errors.

## Regression analysis:

Table 21: Regression Analysis Results for Sub-Hypothesis Three

| Model | | Non-standardized Coefficients | | Stan-dardized Coeffi-cients | t-Test | Signifi-cance |
|---|---|---|---|---|---|---|
| | | Beta | Standard Error | Beta | | |
| 1 | Constant | 0.576 | 0.113 | 0.821 | 5.086 | 0.000 |
| | Human element | 0.842 | 0.035 | | 24.054 | 0.000 |

Source: the author

Table 21 shows that the t-test values for the human element variable are statistically significant at the 0.05 significance level, indicating the strength of the regression relationship between the human element and the competitive capacity of the Aden Container Terminal.

From the preceding tables, one can conclude the following:

- The significance level of both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between the human element and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient indicates a positive linear relationship between the human element and the competitiveness of the Aden Container Terminal.
- The significance level of the overall regression equation (F-test) was less than 0.05, suggesting the reliability of the estimated regression model and the possibility of generalizing the sample results to the study population.
- The beta coefficients suggest that the human element influences the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation is unlikely to be due to chance.
- Based on the above, the researcher can accept the hypothesis that there is a positive relationship between the human element and the competitiveness of the Aden Container Terminal.

The fourth sub-hypothesis states: There is a positive relationship between safety and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

## Correlation coefficient:

Table 22 illustrates the correlation coefficient between safety as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 22: Correlation Coefficient for the Fourth Sub-Hypothesis

| Variable | Test | The competitive capability of the Aden Container Terminal |
|---|---|---|
| Security | Correlation coefficient | 0.747 |
| | Significance | 0.000 |

Source: The author

From table 22, it is evident that there is a statistically significant correlation of 74.7% at a significance level of 0.05 between safety and the competitiveness of the Aden Container Terminal.

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## Coefficient of determination

Table 23: Coefficient of Determination for the Fourth Sub-Hypothesis

| Independent variable | Coefficient of determination | Adjusted coefficient of determination | Standard error |
|---|---|---|---|
| Security | 0.557 | 0.556 | 0.2864 |

Source: The author

Table 23 indicates that the coefficient of determination (R^2 = 0.557), meaning that safety explains 55.7% of the variability in the competitiveness of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression relationship, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

## The analysis of variance (ANOVA) test

Table 24: Analysis of Variance for the Fourth Sub-Hypothesis

| Title | Sum of squares | Degrees of freedom | Mean square | F | Significance |
|---|---|---|---|---|---|
| Regression | 28.925 | 1 | 28.925 | 352.76 | 0.000 |
| Residuals | 22.959 | 280 | 0.082 | | |
| Total | 51.884 | 281 | | | |

Source: The author

From table 24, it is evident that there is a statistically significant positive correlation between safety and the competitiveness of the Aden Container Terminal. This is demonstrated by the F-value, which is statistically significant at a significance level of 0.05. This indicates the validity and substance of the relationship between the variables, ensuring the quality of the framework and the reliability of the results without errors.

## Regression analysis:

Table 25: Regression Analysis Results for the Fourth Sub-Hypothesis

| Model | | Non-standardized Coefficients | | Standardized Coefficients | t-Test | Significance |
|---|---|---|---|---|---|---|
| | | Beta | Standard Error | Beta | | |
| 1 | Constant | 1.533 | 0.094 | 0.747 | 16.235 | 0.000 |
| | Safety | 0.527 | 0.028 | | 18.782 | 0.000 |

Source: The author

From table 25, it is evident that the t-test values for the safety variable are statistically significant at a significance level of 0.05. This indicates the strength of the regression relationship between safety and the competitiveness of the Aden Container Terminal.

From the preceding tables, one can infer the following:

- The significance level of both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between safety and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient suggests a positive linear relationship between safety and the competitiveness of the Aden Container Terminal.
- The significance level of the overall regression equation (F-test) was less than 0.05, indicating the reliability of the estimated regression model and the possibility of generalizing the sample results to the study population.
- The beta coefficients indicate that safety influences the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation is unlikely to be due to chance.
- Based on the above, the researcher can accept the hypothesis that there is a positive relationship between safety and the competitiveness of the Aden Container Terminal.

The fifth sub-hypothesis states: There is a positive relationship between the environment and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

## Correlation coefficient:

Table 26 illustrates the correlation coefficient between the environment as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 26: Correlation Coefficient for the Fifth Sub-Hypothesis

| Variable | Test | The competitive capability of the Aden Container Terminal |
|---|---|---|
| Environment | Correlation coefficient | 0.811 |
| | Significance | 0.000 |

Source: The author

Table 26 shows a statistically significant correlation of 81.1% at a 0.05 significance level between the environment and the competitiveness of the Aden Container Terminal.

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## Coefficient of determination

Table 27: Coefficient of Determination for the Fifth Sub-Hypothesis

| Independent variable | Coefficient of determination | Adjusted coefficient of determination | Standard error |
|---|---|---|---|
| Environment | 0.658 | 0.657 | 0.2516 |

Source: The author

Table 27 indicates that the coefficient of determination (R^2 = 0.658), meaning that the environment explains 65.8% of the variability in the competitiveness of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression relationship, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

## The analysis of variance (ANOVA) test

Table 28: Analysis of Variance for the Fifth Sub-Hypothesis

| Title | Sum of squares | Degrees of freedom | Mean square | F | Significance |
|---|---|---|---|---|---|
| Regression | 34.162 | 1 | 34.162 | 539.75 | 0.000 |
| Residuals | 17.722 | 280 | 0.063 | | |
| Total | 51.884 | 281 | | | |

Source: The author

Table 28 clearly shows a significant positive correlation between the environment and the competitiveness of the Aden Container Terminal. This is evident from the F-value, which is statistically significant at a 0.05 significance level, indicating the validity and substance of the relationship between the two variables, the quality of the framework, and the reliability of the results without errors.

## Regression analysis:

Table 29: Regression Analysis Results for the Fifth Sub-Hypothesis

| Model | | Non-standardized Coefficients | | Standardized Coefficients | t-Test | Signifi-cance |
|---|---|---|---|---|---|---|
| | | Beta | Standard Error | Beta | | |
| 1 | Constant | 0.959 | 0.101 | 0.811 | 9.495 | 0.000 |
| | Environ-ment | 0.714 | 0.031 | | 23.232 | 0.000 |

Source: The author

Table 29 shows that the t-test values for the environment variable are statistically significant at a 0.05 significance level. This indicates the strength of the regression relationship between the environment and the competitiveness of the Aden Container Terminal.

One can conclude from the preceding tables the following:

- The significance level for both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between the environment and the competitive capacity of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient implies a statistically significant positive correlation between the environment and the competitive capacity of the Aden Container Terminal.
- The significance level for the overall regression equation (F-test) was less than 0.05, suggesting that we can rely on the estimated regression model and therefore generalize the sample results to the study population.
- The Beta coefficient values indicate that the environment affects the competitive capacity of the Aden Container Terminal to varying degrees, and this interpretation cannot be attributed to chance.
- Therefore, the researcher can accept the hypothesis that there is a positive relationship between the environment and the competitive capacity of the Aden Container Terminal.

The sixth sub-hypothesis states: There is a positive relationship between energy and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

## Correlation coefficient:

Table illustrates the correlation coefficient between energy as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 30: Correlation Coefficient for the Sixth Sub-Hypothesis

| Variable | Test | The competitive capability of the Aden Container Terminal |
|---|---|---|
| Energy | Correlation coefficient | 0.736 |
| | Significance | 0.000 |

Source: The author

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The preceding table indicates a statistically significant correlation of 73.6% at a significance level of 0.05 between energy and the competitiveness of the Aden Container Terminal.

## Coefficient of determination

Table 31: Coefficient of Determination for the Sixth Sub-Hypothesis

| Independent variable | Coefficient of determination | Adjusted coefficient of determination | Standard error |
|---|---|---|---|
| Energy | 0.541 | 0.541 | 0.2916 |

Source: The author

The preceding table indicates that the coefficient of determination (R^2 = 0.541), which means that energy explains 54.1% of the variation in the competitive capacity of the Aden Container Terminal. The remaining percentage is explained by other variables that were not included in the regression relationship, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

## The analysis of variance (ANOVA) test

Table 32: Analysis of Variance for the Sixth Sub-Hypothesis

| Title | Sum of squares | Degrees of freedom | Mean square | F | Signifi-cance |
|---|---|---|---|---|---|
| Regression | 28.084 | 1 | 28.084 | 330.39 | 0.000 |
| Residuals | 23.8 | 280 | 0.085 | | |
| Total | 51.884 | 281 | | | |

Source: The author

The preceding table indicates a statistically significant positive correlation between energy and the competitiveness of the Aden Container Terminal. This is evident from the F-value, which is statistically significant at a significance level of 0.05. This signifies the validity and substance of the relationship between the variables, ensuring the quality of the framework and the reliability of the results without errors.

## Regression analysis:

Table 33: Regression Analysis Results for the Sixth Sub-Hypothesis

| Model | | Non-standardized Coefficients | | Standardized Coefficients | t-Test | Signifi-cance |
|---|---|---|---|---|---|---|
| | | Beta | Standard Error | Beta | | |
| 1 | Constant | 1.767 | 0.085 | 0.736 | 20.805 | 0.000 |
| | Energy | 0.478 | 0.026 | | 18.177 | 0.000 |

Source: The author

Table 33 indicates that the "t" test values for the energy variable are statistically significant at a significance level of 0.05. This demonstrates the strength of the regression relationship between energy and the competitive capacity of the Aden Container Terminal.

From the preceding tables, the following conclusions can be drawn:

- The significance level for both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between energy and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient indicates a positive relationship between energy and the competitiveness of the terminal.
- The significance level for the overall regression equation (F-test) was less than 0.05, suggesting that the estimated regression model can be relied upon and that the sample results can be generalized to the study population.
- The Beta coefficients indicate that energy affects the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation cannot be attributed to chance.
- Therefore, the researcher can accept the hypothesis that there is a positive relationship between energy and the competitiveness of the Aden Container Terminal.
- From these results, the validity of the study's main hypothesis is evident, namely the presence of a positive relationship between the automation of operational processes and the competitiveness of the Aden Container Terminal.

## RESULTS

The study revealed several key findings:

- A significant relationship exists between automating operational processes and boosting competitiveness at Aden Container Terminal.
- The absence of a robust automation system for operational processes diminishes the appeal of the terminal to logistics companies and shipping firms, thereby negatively affecting its ability to fulfill commitments to predetermined customers.
- Implementing automation in operational processes at the terminal and providing suitable equipment in terms of size, modernity, and quantity lead to a reduction in the time required for container handling and ensure the attainment of desired quality in task completion.

- Developing comprehensive plans for integrating process automation enhances communication, cooperation, and coordination among different departments at the terminal, thereby facilitating development, improvement, and enhanced coordination of activities.
- Insufficient investment in modern technology and resources for automation negatively impacts the development of employees' skills, capabilities, and experiences.
- Automation of processes at the terminal helps mitigate the risk of accidents resulting from human errors and ensures the effective implementation of plans, work programs, evaluation of results, and alignment with set standards.
- Challenges exist in improving safety levels during process automation at the terminal due to inadequate attention to defining objectives, strategies, mechanisms, and developing various scenarios for implementing an effective safety and security system.
- Increased investment in enhancing environmental impact and operational processes at the terminal is crucial for adapting to changing variables and ensuring sustainability.
- Developing a more effective strategy for utilizing energy sources at the terminal is essential to improve performance, achieve strategic objectives, develop service delivery methods, and introduce new services relying on process automation.

## RECOMMENDATION

Based on these findings, the following recommendations are suggested:

- Emphasizing the strong correlation between automating operational processes and enhancing competitiveness at Aden Container Terminal and leverage the positive effects of automation to boost competitiveness.
- Implementing a robust automation system for operational processes at the terminal to enhance its attractiveness to logistics companies and shipping firms, thereby meeting commitments to predetermined customers effectively.
- Focusing on achieving automation of operational processes and providing appropriate equipment to reduce container handling time and ensure high-quality task completion.
- Developing comprehensive plans for integrating process automation to enhance communication, cooperation, and coordination among different departments at the terminal.
- Investing in modern technology and resources to support automation, thereby enhancing employees' skills, capabilities, and experiences.
- Prioritizing automation of processes to mitigate the risk of accidents resulting from human errors and ensure compliance with set standards.
- Addressing challenges in improving safety levels during process automation by defining objectives, strategies, mechanisms, and implementing effective safety and security measures.
- Increasing investment in improving environmental impact and operational processes at the terminal to adapt to changing variables effectively.
- Developing a comprehensive strategy for utilizing energy sources at the terminal to enhance performance, achieve strategic goals, and introduce innovative services relying on process automation.

Future studies could explore the long-term effects of advanced automation technologies and artificial intelligence on the sustainability and strategic growth of the Aden Container Terminal, including the potential for integrating emerging technologies such as blockchain for enhanced security and transparency, the impact on workforce dynamics and training needs, and the environmental implications of automation. Additionally, comparative studies with other leading global container terminals could provide further insights into best practices and innovative solutions for maintaining and enhancing competitiveness.

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