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Effect of Technological Infrastructure on Operational Efficiency at the Inland Container Depot (ICD) In Naivasha, Kenya

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Abstract

In 2017, the Kenya Revenue Authority's customs department encountered 400 complaints from importers and agents about delays in container clearance, despite the introduction of the Single Electronic Window System in 2014. Challenges persist, particularly in rail transport from Mombasa to the Inland Container Depot, due to inadequate verification bays and warehousing facilities, a contrast to China's efficient system. Additionally, the manual documentation process at the Naivasha ICD and fragmented communication networks exacerbate delays, impacting regional cooperation and business performance for clearing agents. This study aimed to investigate the impact of technological infrastructure on operational efficiency at the Inland Container Depot (ICD) in Naivasha, Kenya. The study adopted the Diffusion of Innovations Theory. The research employed an explanatory survey research design, targeting 1,200 clearing and forwarding agents at the Inland Container Depot, with 350 of them situated in Nairobi. Using Yamane's formula, a sample size of 201 was selected to ensure proper representation. These resulted in a target of 174 clearing and forwarding agents, 12 transporters, and 15 customs officials, totaling 201 participants. Data was collected through open and closed structured questionnaires, yielding both qualitative and quantitative data. Descriptive statistical tools such as mean scores, standard deviation, and percentages were used for analysis, while inferential statistics involved correlation and regression analysis. The regression analysis results revealed that technological infrastructure ($\beta=0.388$, $P=0.000$) has a positive and significant effect on operational efficiency. The study concluded that technological infrastructure positively affects the operational efficiency of ICDs. The study advised to ensure that the technological infrastructure they are making use of is up to date.

Keywords: *Technological infrastructure, operational efficiency, Inland Container Depots (ICDs)*

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1. Introduction

Operational efficiency within the logistics and supply chain sectors is essential for ensuring that organizations can deliver services effectively and at a minimal cost. This efficiency is especially vital in Inland Container Depots (ICDs), which are key components in the distribution and transportation networks. The performance of ICDs is often gauged using various metrics, including turnaround time, container handling rate, and resource utilization rates, which directly impact logistics costs and service quality (Notteboom, 2006). Thai (2001) in particular pointed out that operational efficiencies are crucial for effective service delivery and cost management, both of which are essential for the growth and sustainability of logistics hubs. This implies that higher operational efficiency not only reduces costs but also enhances customer satisfaction and competitive edge.

The efficiency of operations in ICDs can be affected by a myriad of factors. Managerial practices, for example, play a significant role in how efficiently resources are allocated and utilized. The management's ability to orchestrate operations smoothly and respond to challenges is key to maintaining high efficiency. Additionally, technology adoption is another pivotal factor. As noted by Panayides and Venus Lun (2009), the integration of advanced technologies in the logistics processes can dramatically improve operational performance by speeding up transactions, improving data accuracy, and facilitating better communication within the supply chain. Empirical research also supports these assertions. For example, studies have shown that the adoption of technology, such as automated container handling systems and advanced data management software, leads to significant improvements in operational efficiency.

These technological advancements not only speed up the handling processes but also reduce errors and downtime, thereby enhancing overall efficiency (Notteboom, 2006). Moreover, operational efficiency in ICDs also hinges on effective resource utilization, which involves optimizing the use of equipment, labor, and infrastructure. According to Robinson (2002), efficient use of resources not only cuts down costs but also speeds up the entire supply chain, leading to improved customer satisfaction and increased profitability.

Inland Container Depots (ICDs) are crucial nodes in global supply chains, optimizing the flow of goods from maritime ports to inland destinations. The infrastructure of these depots, which includes an array of physical assets, technological systems, service facilities, and integrative elements with other transport modes, underpins their operational efficiency. Studies across various facets of ICD operations underscore the significant impact of this infrastructure on the overall efficacy of freight handling and management. Technological infrastructure specifically plays a crucial role in ICDs. The deployment of sophisticated Information Technology systems, including Terminal Operating Systems (TOS) and RFID technology, revolutionizes container tracking and management. González-Ramírez et al., in their 2012 study, demonstrated how RFID implementation markedly decreases processing times and reduces dwell times, leading to a more fluid container transit through the depot. These technologies ensure accuracy, reduce human error, and improve communication within the logistical network, further supporting operational efficiency.

1.1 Problem Statement

In 2017, the customs department of the Kenya Revenue Authority (KRA), via its customer service desk, handled 400 complaints from importers and licensed customs clearing agents regarding delays in container clearance (Wanyama, 2017). Despite the implementation of the Single Electronic Window System in 2014, intended to streamline the process, delays persist, particularly in the rail transport of imports from Mombasa to the Inland Container Depot (ICD) and vice versa for exports and empty containers. This inefficiency is compounded by the lack

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of verification bays and sufficient warehousing facilities, which are crucial for effective cargo handling and storage. By contrast, in more technologically advanced countries like China, the adoption of a more efficient Single Window system enables customs clearance in less than three days, a stark difference highlighted by Trent and Roberts (2009).

Further complicating matters, ports like Cape Town have advanced towards more computerized customs and logistics procedures, unlike the Naivasha ICD where the documentation process still remains partly manual due to the absence of the KWATOS system, leading to slower processing times and increased potential for human error, as pointed out by the World Bank in 2016. A 2020 NCTTCA survey report on the Naivasha ICD reveals a lack of interconnectivity among systems used by various stakeholders, leading to inefficiencies and communication barriers. Conversely, customs clearances through Jomo Kenyatta International Airport (JKIA) in Nairobi are completed within a maximum of two days, underscoring the inconsistency in customs clearance procedures across different points in Kenya, including the inland depot and JKIA. This study aimed to investigate the effect of technological infrastructure on operational efficiency at the Inland Container Depot (ICD) in Naivasha, Kenya.

1.2 Research Objective

To investigate the effect of technological infrastructure on operational efficiency at the Inland Container Depot (ICD) in Naivasha, Kenya.

1.3 Research Hypothesis

$H_{02:}$ Technological infrastructure has no significant effect on operational efficiency at the Inland Container Depot (ICD) in Naivasha, Kenya.

2. Literature Review

2.1 Theoretical Review

The study was anchored on diffusion of innovations theory. Developed in 1962, Everett Rogers' Diffusion of Innovations Theory provides a framework for comprehending the whys, hows, and rates of dissemination of new concepts and technology within social systems, including corporate operations such as Inland Container Depots (ICDs). To better comprehend the various degrees of receptivity to change and new technology inside an organization, the theory divides adopters into five groups: innovators, early adopters, early majority, late majority, and laggards (Rogers, 1962).

In the setting of ICDs, which are pivotal in logistics and supply chain management, the diffusion of new technologies—such as automated gate systems, RFID tracking, and advanced data analytics—can significantly impact operational efficiency and service delivery. Rogers' theory can help in examining how these technologies are adopted and the subsequent effects on ICD operations (Dearing & Cox, 2018). For instance, by understanding the attributes that influence technology adoption, relative advantage, compatibility, complexity, trial-ability, and observability, management can better strategize the introduction and integration of new systems (Rogers, 2003).

Using Rogers' framework, ICD management can initiate studies to pinpoint the adopter categories among their staff and strategize accordingly. For example, recognizing early adopters and engaging them in pilot programs can facilitate smoother implementation of new technologies. These programs not only provide practical feedback but also serve as demonstrative models for other staff members, potentially easing the transition across the depot. Additionally, adjusting technologies to meet the specific needs of the depot's environment enhances compatibility, which Rogers identified as crucial for adoption (Rogers, 2003).

Empirical research in logistics technology adoption supports this approach. Studies on electronic data interchange (EDI) systems have highlighted how perceived complexity and compatibility influence adoption decisions in logistics firms (Premkumar et al., 1994). Similarly, research on RFID implementation in supply chain operations suggests that trialability and tailored adjustments can significantly improve user acceptance and effectiveness (Sabbaghi & Vaidyanathan, 2008).

This idea was considered pertinent to the research at hand. Several studies on technological infrastructure have utilized the theory as its theoretical foundation, and it can apply to concepts, artifacts, and approaches in the field of information technology. A new concept, action, or product is adopted by individuals as part of a social system as a result of diffusion. Adoption occurs when a company makes a change from its past practices, such as implementing new systems to improve operational performance. To be adopted, an idea, behavior, or product must be perceived as novel or original.

2.2 Empirical Review

Denis (2020) undertook a thorough examination to identify the factors that contributed to the optimization of Embakasi dry port's activities in his work titled Determinants of Dry Port Performance in Kenya: A Case of the Internal Container Depot, Nairobi. The primary aim was to address trade facilitation challenges and ensure seamless container flow at the Mombasa Seaport. This inquiry specifically delved into the determinants influencing dry port performance with a strategic focus on enhancing revenue collection. Several explanatory variables were included in the research framework, such as infrastructure, stakeholder cooperation, people capacity, and information and communication technology (ICT). The theoretical underpinnings of the study drew from stakeholder theory, institutional theory, and agency theory to offer a robust analytical foundation.

The research used an explanatory design and aimed to gather data from 838 people who were involved in international trade. This group included upper-level management from the Kenya Ports Authority (KPA), the Kenya Revenue Authority (KRA), the customs and border control agency, clearing and forwarding brokers, and other related organizations. Using a stratified random sampling procedure, 271 participants were picked from this pool. For the 2018–2019 fiscal year, data was collected at the KRA offices and the Nairobi Inland Container Depot (ICD). Denis (2020) states that the analysis used descriptive and inferential statistical approaches, which were made possible using SPSS, to investigate the interrelationships of the variables.

The outcomes of the multiple regression analysis showed that there were notable positive impacts of information and communication technology (ICT), infrastructure ($\beta2=0.565$, $p<0.05$), personnel capacity ($\beta3=0.094$, $p<0.05$), and stakeholder collaboration ($\beta4=0.22$, $p<0.05$) on the performance of the dry port. Importantly, the p-values for all variables were less than 0.05, suggesting that they were statistically significant. The model summary further highlighted a substantial 77.2% variance in dry port performance attributable to fluctuations in

ICT, infrastructure, personnel capacity, and stakeholder cooperation. Consequently, the study concluded that ICT, infrastructure, personnel capacity, and stakeholder cooperation significantly and positively influenced dry port performance. According to Dennis (2020), KRA should stimulate infrastructure development inside the dry port by establishing policies that encourage the construction of improved facilities and by promoting productive relationships with other border agencies participating in customs clearing processes.

In their study, Muhajji, Rappe, Halim, and Yunus (2024) examined how infrastructure and technology might enhance operational efficiency. The research strategy was a mixed-methods one, integrating quantitative results from surveys with semi-structured interviews with influential people in fields as varied as manufacturing, finance, and city planning. Through the use of statistical and thematic analysis approaches, the data were examined. According to the research, productivity, cost-effectiveness, and innovation may be greatly improved by combining cutting-edge technology like IoT, automation, and AI with strong IT and physical infrastructure. These findings are in line with the dynamic capacity theory, which stresses the significance of a company's capacity for ongoing innovation and adaptation. The necessity for ongoing staff training, high initial expenditures, and technology obsolescence were all mentioned as obstacles. The importance of creating generic models that may be used in different settings to make conclusions more applicable is also highlighted by the findings.

3. Methodology

The research employed an explanatory survey research design, targeting 1,200 clearing and forwarding agents at the Inland Container Depot, with 350 of them situated in Nairobi. Using Yamane's formula, a sample size of 201 was selected to ensure proper representation. These resulted in a target of 174 clearing and forwarding agents, 12 transporters, and 15 customs officials, totaling 201 participants. Data was collected through open and closed structured questionnaires, yielding both qualitative and quantitative data. Descriptive statistical tools such as mean scores, standard deviation, and percentages were used for analysis, while inferential statistics involved correlation and regression analysis.

4. Results and Discussion

4.1 Descriptive Analysis

4.1.1 Technological Infrastructure

Table 1 shows the descriptive statistics for technological infrastructure.

Table 1: Summary Statistics for Technological Infrastructure

	N	Mean	SD	Skewness	Kurtosis
The implementation of Terminal Operating Systems (TOS) significantly enhances decision-making processes within ICDs	165	4.24	1.064	-1.438	1.33
Automated Gate Systems (AGS) reduce processing times and improve overall operational efficiency at ICDs	165	4.22	1.032	-1.204	0.613
Inventory Management Systems (IMS) contribute to minimizing container dwell times and optimizing storage space within ICDs	165	4.05	1.16	-1.01	-0.086
Advanced communication technologies like RFID and mobile communications improve collaboration and coordination among supply chain stakeholders in ICD operations	165	3.8	1.312	-0.968	-0.168
The integration of IoT technology enhances visibility and traceability, thereby increasing operational efficiency in container handling at ICDs	165	3.93	1.328	-1.036	-0.128
Cloud-based platforms facilitate real-time data sharing and enhance operational flexibility across ICD operations	165	4.32	0.968	-1.814	3.38
Technological advancements in ICDs, such as AI and blockchain integration, improve security, transparency, and efficiency in logistics operations	165	3.77	1.252	-0.855	-0.236
Aggregate Mean	**165**	**4.05**			

A mean of 4.24 revealed that the respondents highly agreed that the implementation of Terminal Operating Systems (TOS) significantly enhances decision-making processes within ICDs. There was a low variability in the responses, as shown by a low std. deviation of 1.064. The distribution of responses was moderately negatively skewed (-1.438), suggesting that more respondents were inclined towards agreement, and a Kurtosis of 1.33 showed a moderate peak.

The respondents highly agreed that Automated Gate Systems (AGS) reduce processing times and improve overall operational efficiency at ICDs, as shown by a mean of 4.22. A low variability in responses was also shown by a Std. Deviation of 1.032. The negative skewness statistic (-1.204) indicated moderate negative skew, revealing that the majority of respondents strongly agree or agree with this statement. A kurtosis value of 0.613 also revealed a peak in the responses.

A mean of 4.05 revealed a high agreement on the statement that Inventory Management Systems (IMS) contribute to minimizing container dwell times and optimizing storage space within ICDs. The standard deviation of 1.16 also showed a low variability in the responses. The negative skewness of -1.01 suggested that the distribution was moderately negatively skewed, and the kurtosis of -0.086 suggested a peakedness in the distribution.

On average, the respondents agreed that Advanced communication technologies like RFID and mobile communications improve collaboration and coordination among supply chain stakeholders in ICD operations, as shown by a mean of 3.8. The low standard deviation of 1.312 indicated a low variability in responses. The negative skewness statistic of -0.968 and a negative kurtosis statistic of -0.168 indicated a slight distribution of the responses.

A high mean value of 3.93 also revealed a high agreement level on the statement The integration of IoT technology enhances visibility and traceability, thereby increasing operational efficiency in container handling at ICDs. There was also a low deviation from the mean, indicating a low variability of the responses, as shown by a standard deviation of 1.328. The skewness statistic of -1.036 and a kurtosis statistic of -0.128 also showed a moderate negative skew, revealing a slight distribution in the responses.

Further, the statement Cloud-based platforms facilitate real-time data sharing and enhance operational flexibility across ICD operations produced a high mean of 4.32, revealing a high level of agreement on the statement. The standard deviation was 0.968 showing a low variability in the responses. Additionally, a skewness and kurtosis of -1.814 and a kurtosis statistic of 3.38 showed moderate distribution of the responses.

Lastly for the statement technological advancements in ICDs, such as AI and blockchain integration, improve security, transparency, and efficiency in logistics operations, majority of the respondents, agreed as depicted by a mean of 3.77. The standard deviation of 1.252 also showed a low variability in the responses produced. The negative skewness -0.855 and kurtosis of 0.236 indicated a strong agreement with this statement among the respondents. The aggregate mean for the variable technological infrastructure was 4.05 which revealed that the respondents greatly agreed with the statements on technological infrastructure. This implied that at ICD Naivasha, the use of technological infrastructure was high.

4.1.2 Operational Efficiency

Table 2 indicates descriptive statistics for operational efficiency.

Table 2: Summary Statistics for Operational Efficiency

	N	Mean	Std. Dev.	Skewness	Kurtosis
Investments in physical infrastructure, such as handling and storage facilities, reduce bottlenecks and improve turnaround times	165	3.99	1.107	-1.107	0.646
Implementing advanced technological solutions, such as ICT systems and automated handling equipment, enhances operational efficiency	165	4.08	1.084	-1.216	0.82
Reliable power infrastructure is crucial for maintaining consistent operational efficiency at the ICD	165	4.08	1.062	-1.224	0.861
Integrating ICT systems like container tracking and terminal operating systems improves coordination and reduces operational inefficiencies	165	4.01	1.142	-1.217	0.734
Effective management of resource utilization contributes to the overall operational efficiency	165	4.04	1.059	-1.041	0.367
Aggregate mean	165	4.04			

For the statement Investments in physical infrastructure, such as handling and storage facilities, reduce bottlenecks and improve turnaround times, the mean was 3.99, meaning that the majority of the respondents agreed with the statement. The low standard deviation (1.107) suggests that there is a relatively low level of variability in responses, indicating a consensus among participants. The negative skewness (-1.107) indicates that the distribution is slightly skewed to the left, suggesting that more respondents are inclined towards agreeing. A kurtosis value of 0.646 showed a moderately peaked distribution.

The average score for the statement implementing advanced technological solutions, such as ICT systems and automated handling equipment, enhances operational efficiency was 4.08, indicating that most respondents concur with the statement. The low standard deviation (1.084) indicates a relatively consistent level of agreement among respondents. The negative skewness (-1.216) suggested a slightly left-skewed distribution, meaning that more respondents lean towards agreement. Moreover, a kurtosis value of 0.82 showed a moderately peaked distribution.

The high mean of 4.08 on the statement Reliable power infrastructure is crucial for maintaining consistent operational efficiency at the ICD similarly indicated that respondents strongly agree with the statement. The low standard deviation (1.062) suggested some variability in responses, but the overall trend is towards agreement. The negative skewness (-1.224) indicates a left-skewed distribution, with a majority of respondents strongly agreeing. A kurtosis statistic of 0.861 also showed a moderately peaked distribution.

Furthermore, a mean of 4.01 showed that the majority of the respondents agreed with the statement Integrating ICT systems like container tracking and terminal operating systems improves coordination and reduces operational inefficiencies. A low standard deviation of 1.142 also showed a low variability in the responses. A skewness statistic of -1.217 further showed a moderately skewed distribution of responses, and a kurtosis value of 0.734 revealed a moderately peaked distribution.

Lastly, for the statement that effective management of resource utilization contributes to the overall operational efficiency, the mean was 4.04, suggesting that, on average, the majority of the respondents agreed. The low standard deviation (1.059) indicated a low level of variability in responses. The negative skewness statistic (-1.041) suggested a slightly left-skewed distribution, meaning that more respondents lean towards agreement. A kurtosis statistic of 0.367 further showed a slightly peaked distribution.

The mean aggregate for operational efficiency was 4.04, revealing that the majority of the respondents agreed with the statements showing a high level of operational efficiency at ICD Naivasha in terms of speed, quality, time, cost, and flexibility.

4.2 Correlation Analysis

To determine the association that exists between the technological infrastructure and the operational efficiency in the study in terms of strength and direction, a correlation analysis was performed. Table 3 presents the correlation matrix showing the correlation coefficients thereof.

Table 3: Correlation Matrix

		Operational efficiency	Technological Infrastructure
Operational efficiency	Pearson Correlation	1	
	Sig. (2-tailed)		
Technological Infrastructure	Pearson Correlation	.642**	1
	Sig. (2-tailed)	0.000	
	N	165	

** Correlation is significant at the 0.01 level (2-tailed).

The results revealed a positive and significant correlation between technological infrastructure and operational efficiency (r=0.642) for a two-tailed test (P=0.000). Therefore, the correlation can be explained to be significant at a 99% confidence level. This means that operational efficiency would increase with an increase in technological infrastructure. This was in line with Lau and Zhao (2016), who quantitatively demonstrated the impact of AGS on operational efficiencies and found a notable 20% reduction in truck idling times at ICDs equipped with automated gates compared to those relying on manual processes.

4.3 Regression Analysis

Table 4 shows regression results on the effect of technological infrastructure on operational efficiency.

Table 4: Regression Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.037	0.253		0.147	0.883
Technological Infrastructure	0.381	0.056	0.388	6.85	0.000

The findings showed that the coefficient for technological infrastructure and operational efficiency was positive and significant ($\beta=0.388$, $P=0.000<0.05$). This implied that technological infrastructure had a positive and significant effect on operational efficiency is positive and significant. This concurred with Denis (2020), who found that ICT, infrastructure, significantly and positively influenced dry port performance. In line with Mambori's (2020) findings that tax knowledge significantly affects tax compliance, this study reached the same conclusions. This finding lends credence to the findings of Suriyadi and Hani (2024), who, at KPP Pratama Binjai, discovered a correlation between tax awareness and compliance.

4.4 Hypothesis Testing

The null hypothesis was that technological infrastructure has no significant effect on operational efficiency at the Inland Container Depot (ICD) in Naivasha, Kenya. The study found that technological infrastructure has a positive and significant effect on operational efficiency ($p=0.000<0.05$), and the null hypothesis was therefore rejected.

5. Conclusion

The study concludes that technological infrastructure positively affects operational efficiency at ICDs. The implementation of Terminal Operating Systems (TOS) significantly enhances decision-making processes. Further, Automated Gate Systems (AGS) reduce processing times and improve overall operational efficiency in ICDs. Furthermore, Inventory Management Systems (IMS) contribute to minimizing container dwell times and optimizing storage space within ICDs. Additionally, advanced communication technologies like RFID and mobile communications improve collaboration and coordination among supply chain stakeholders in ICD operations. It is also concluded that the integration of IoT technology enhances visibility and traceability, thereby increasing operational efficiency in container handling at ICDs. The study also concludes that cloud-based platforms facilitate real-time data sharing and enhance operational flexibility across ICD operations. Lastly, the study makes a conclusion that technological advancements in ICDs, such as AI and blockchain integration, improve security, transparency, and efficiency in logistics operations.

6. Recommendations

To improve operational efficiency at Naivasha Inland Container Depots (ICDs) in Kenya, policymakers should focus on infrastructure development, technological advancements, and streamlining processes. Specifically, they should invest in upgrading infrastructure, implement efficient port management systems, and foster public-private partnerships. They should specifically ensure the Naivasha ICD has all necessary infrastructure, including control gates, weighbridges, verification areas, a re-marshalling yard, medical facilities, and infrastructure for perishable goods. To improve operational efficiency at Naivasha Inland Container Depots (ICDs) in Kenya, financial institutions should prioritize infrastructure upgrades, streamlined processes, and technology adoption. This includes investing in modern warehousing, supporting the rail network, and implementing digital solutions to improve cargo tracking and clearance.

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