



Lisbon School
of Economics
& Management
Universidade de Lisboa

MASTERS IN MANAGEMENT AND INDUSTRIAL STRATEGY

MASTER'S FINAL WORK DISSERTATION

**DIGITAL TRANSFORMATION IN AFRICAN PORTS: AN ANALYSIS OF
BARRIERS, ENABLERS AND BENEFITS**

DIOGO ANTÓNIO FERREIRA MARQUES

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GLOSSARY

IAPH - International Association of Ports and Harbors.

ICT - Information and Communication Technology.

IMO - International Maritime Organization.

IOT - Internet of Things.

IT - Internet.

JUL - Janela Única Logística.

MSW - Maritime Single Window.

PCS - Port Community System.

PPP - Public-Private Partnerships.

SSATP - Sub-Saharan Africa Transport Policy Programme.

VTMS - Vessel Traffic Management Systems.

ABSTRACT

Digital Transformation has become a strategic priority for ports worldwide, offering opportunities to improve operational efficiency, transparency, and competitiveness. However, the pace and success of digitalization vary considerably across African ports due to the presence of multiple institutional, technological, and organizational challenges. This dissertation investigates the barriers, enablers, and benefits of digital transformation in African ports, with focus on the Port of Mombasa and Port of Banjul. Furthermore, the study compares these findings with insights obtained from the Porto de Lisboa and Porto de Setúbal in Portugal to identify similarities and differences in the factors influencing digitalization processes across different port environments.

The research adopts a qualitative comparative case study approach with data collected through a review of academic literature and industry publications, complemented by a semi-structured interview conducted with the President of Porto de Lisboa and Porto de Setúbal. The interview data was analysed using MaxQDA software through a deductive thematic coding approach based on six dimensions from the literature.

According to the study results, achieving success in the digital transformation process is contingent upon the interdependence of technology, organizations and institutions as opposed to merely relying upon technology. A combination of governance quality, the existence of an adequate Information and Communication Technology infrastructure, workforce capabilities, stakeholder collaborations and the presence of public-private partnerships were the primary enablers of digitalization, whereas deficiencies in infrastructure, skills shortages, institutional constraints and cyber security vulnerabilities were the major barriers to digitalization. Digitalization was found to create benefits such as increased operational efficiency, heightened levels of transparency, better information-sharing capabilities, improved coordination among stakeholders and increased ability to compete.

This dissertation contributes to the literature by providing a comparative analysis of digital transformation in African and Portuguese port environments and by highlighting the interconnected nature of the factors influencing digitalization outcomes.

KEYWORDS: Enablers; Barriers; Benefits; Digital Transformation; African Ports.

RESUMO

A transformação digital tornou-se uma prioridade estratégica para portos em todo o mundo, oferecendo oportunidades para melhorar a eficiência operacional, a transparência e a competitividade. No entanto, o ritmo e o sucesso da digitalização variam consideravelmente entre os portos africanos, devido à presença de múltiplos desafios institucionais, tecnológicos e organizacionais. Esta dissertação investiga as barreiras, os fatores facilitadores e os benefícios da transformação digital em portos africanos, com foco nos portos de Mombaça e de Banjul. Além disso, o estudo compara as informações obtidas com os portos de Lisboa e de Setúbal, em Portugal, para identificar semelhanças e diferenças nos fatores que influenciam os processos de digitalização em diferentes ambientes portuários.

A pesquisa adota uma abordagem de estudo de caso comparativo qualitativo com dados coletados por meio de revisão da literatura acadêmica e de publicações do setor, complementada por uma entrevista semiestruturada realizada com o presidente dos portos de Lisboa e de Setúbal. Os dados da entrevista foram analisados com o software MaxQDA, utilizando uma abordagem de codificação temática dedutiva baseada em seis dimensões que vieram da literatura.

De acordo com os resultados do estudo, o sucesso no processo de transformação digital depende da interdependência entre tecnologia, organizações e instituições, em vez de depender apenas da tecnologia. Uma combinação de qualidade de governança, existência de infraestrutura adequada de Tecnologia de Informação e Comunicação, capacitação da força de trabalho, colaboração entre as partes interessadas e presença de parcerias público-privadas constituiu os principais fatores facilitadores da digitalização, por outro lado, deficiências de infraestrutura, escassez de competências, restrições institucionais e vulnerabilidades de segurança cibernética foram as principais barreiras. Constatou-se que a digitalização gera benefícios como maior eficiência operacional, níveis elevados de transparência, melhores capacidades de compartilhamento de informações, coordenação aprimorada entre as partes interessadas e maior competitividade.

Esta dissertação contribui para a literatura ao fornecer uma análise comparativa da transformação digital em ambientes portuários africanos e portugueses e ao destacar a natureza interconectada dos fatores que influenciam os resultados da digitalização.

Palavras-Chave: Facilitadores; Barreiras; Benefícios; Transformação Digital; Portos Africanos.

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1. INTRODUCTION

International trade is dependent on port facilities to move goods into and out of countries. The efficient functioning and competitive nature of ports is becoming more critical for economic growth and for all regions of the world becoming more integrated as a global economy because the vast majority (about 80%) of world trade (by volume) uses water transportation. Over the past decade or so, technological advances have radically changed the maritime industry, and all ports worldwide are adopting digital technologies into their operations to increase the performance of operations and create resilience in supply chains.

However, even though much of the world has seen rapid progression regarding the digital transformation of the shipping industry, the rate of adoption is still unequal across regions of Africa. Some ports within Africa have implemented significant digital programs to change operation processes while many of them experience substantial challenges relating to port infrastructure, governance, financing, stakeholder coordination, human capital development, and cybersecurity. These issues are limiting the ability of African ports to take full advantage of the opportunities created through the use of digital technologies and remain competitive among the growing number of digital ports in other regions of the world.

Given the strategic importance of ports for economic development and regional integration, understanding the factors that influence digital transformation in African ports is both academically relevant and practically significant. This dissertation focuses on showing the barriers and enablers that shape digital transformation processes and examines how these factors affect the realization of digitalization benefits within African port environments.

The literature further shows a variety of barriers and enablers that influence digital transformation outcomes. As well has the findings “Barriers are defined as all the factors that hinder or delay the adoption and effective use of digital technologies” (Vitor Caldeirinha, 2026). Conversely, “enabler is any factor that accelerates or increases the likelihood of success of digital transformation processes” (Vitor Caldeirinha, 2026).

There is a growing amount of literature that looks at the positive impacts of digitalization and the implementation of smart technology in ports, however, we find

there is little literature investigating the specific obstacles and enablers for digital transformation in African ports. Existing studies often focus on technological implementation or operational performance improvements. Furthermore, there is limited comparative research exploring how the experiences of African ports differ from those of ports operating in more advanced digital environments. This gap creates an opportunity to generate new insights regarding the factors that facilitate or constrain digital transformation across different institutional contexts. To address this gap, this dissertation examines the cases of the Port of Mombasa and the Port of Banjul and complements the analysis with insights obtained through an interview conducted with the President of the Porto de Lisboa and Porto de Setúbal.

This dissertation consists of five chapters. Chapter 2 presents the literature review and builds the conceptual framework. Chapter 3 presents the methodology section, which outlines the qualitative research technique and the use of MaxQDA software. In Chapter 4, the empirical findings, a cross-case study approach are reported, and the discussion is presented while Chapter 5 focuses on the conclusion, highlights the limitations of the research, and offers suggestions for future investigations.

Research Questions

What are the main barriers, enablers and benefits of digital transformation in African ports?

How do the findings from the African ports compare with those obtained from the Portuguese port context?

2. LITERATURE REVIEW

This section intends to make a balanced review of the topic in research where it has the barriers of digitalization, and which are the benefits of that digitalization in African Ports. It also aims to provide information and help the reader understand the study done on this dissertation. It starts by giving a small introduction on the meaning of ports with focus on African ports, showing how important these ports are for the respective locations where they are implemented. Then, it shows some impacts of digitalization, problems on the workforce, infrastructure and more detailed barriers found during the years.

Lastly, in order to clarify the reading, this section combines relevant literature and essential information for the reader to be able to understand the main topics of this dissertation.

2.1 Introduction to the role of Ports, focusing on African Ports

Ports are key players in global commerce, accounting for more than eighty percent of cargo transported throughout the world and representing an essential part of the international transportation network (Lun *et al.* 2023; Khalid *et al.* 2008). “It is emphasized that in the conditions of intense competition in the global transport services market, the use of innovations of port enterprises is becoming a key success factor for seaports” (Inna V. Golubeva, 2024). “Ports stimulate economic sectors and support trade relations by providing essential infrastructure to handle diverse cargo” (Matekenya & Siyanda, 2025). “Ports are the backbone of international trade and crucial nodes in global supply chains” (Chaula, 2025).

In Africa, ports face a lot of challenges like infrastructure deficiencies, high traffic density and operational constraints (Bichou, 2021). Additionally, to these challenges are institutional inefficiency, weak governance structures and limited private sector participation, which limit the port’s ability to serve as a competitive trade gateway (Fraser & Notteboom 2016; Gumede & Chasomeris 2018).

Ports are necessary for Africa’s economic development, serving as gateways for international trade (Mlambo, 2021). Africa depends on maritime transport, and these ports are important to connect countries to global markets and foster economic growth (Institute for Security Studies, 2020). However African ports do more than support economic progress (Almeida & Okon, 2025), as recognized by Mohamed-Cherif & Ducruet (2016),

they are also vital to national and regional integration and infrastructure advancement. However, they face many challenges that diminish their capability (Almeida & Okon, 2025). Poor infrastructure, congestion and slow custom procedures lead to longer delays and higher shipping costs for cargo (Ayesu & Boateng, 2024). And with that investment to upgrade facilities, use digital processes and improve links to other transport systems are needed so that ports can produce their full value to stimulate economic growth in Africa (Almeida & Okon, 2025).

2.2 Implementation of Digitalization and its impact in African Ports

Digitalization is now a solution to many port challenges in the world (Almeida & Okon, 2025). According to the International Maritime Organization, ports that embrace digital transformation are in a better position to manage increased trade volume and change caused by market disruptions (IMO, 2024). (Kaburu, 2022) defined digitalization “as the use of digital technology to transform the way business is operated.”

Literature such as Kraus *et al.* (2021) and Omol (2024), report that an organization must comprehensively transform digitally through alignment of the organization’s culture, processes and people. “It requires a deliberate alignment of organizational culture, processes and human factors to ensure that digital initiatives are effective and sustainable” (Almeida & Okon, 2025). Some ports have established best practices in logistics, handling and customs, thereby reducing turnaround time and increasing processing efficiency (Kaliszewski *et al.*, 2020). Other ports face difficulties such as bureaucratic bottlenecks, inefficient customs processes and labour disputes, that could lead to delays and costs (Mazibuko *et al.*, 2024). Some barriers to improving the level of digitalization are the lack of policy direction and the small sample of obligatory regulations (Almeida & Okon, 2025).

The prevailing consensus is that governments (directly or through the port authorities) need to lead this digital transformation process (SSATP, 2024). “Digital intensity has been defined as the level of investment in technology applications to transform company operations while the intensity of management transformation refers to how much an organization invests in leadership capabilities required to ensure it actually attains its vision of digital transformation” (Kaburu, 2022).

Existing literature showed that digitalization of processes and operations has had a positive impact on performance and efficiency levels and facilitated communication with different stakeholders (Balci, 2021). Some benefits that came from digitalization are increased integration with various stakeholders and improved performance and efficiency levels (Balci, 2021). Digitalization and electronic data exchange aims to speed up the processes in ports in an efficient way, as a main objective, but the importance of contact with key stakeholders for successful transitions and its implementation cannot be ignored (IAPH, 2020). Stakeholders are necessary in early stages of development (Heilig *et al.* 2017).

Ports can improve operational efficiency, reduce waiting times, and minimize logistics costs if they adopted modern loading and unloading technologies (Zerbino, Aloini, Dulmin & Mininno, 2019). Digitalization also facilitates better data management, greater transparency, and collaboration among stakeholders, including governments and port operators (Sanchez-Gonzalez *et al.*, 2022). Ports that have implemented automation systems to monitor ship schedules could also reduce ship waiting times, leading to cost savings and upgraded customer service (Dong, Liu, Tae-Woo Lee, Chi & Ye, 2023).

2.3 Workforce and ICT Infrastructures

Digitalization improves port performance by merging advanced technology with operations, thereby improving efficiency, sustainability, and service quality (Sirajuddin *et al.* 2025).

In the world of maritime logistics, the need for skilled, competent, and certified port workers is becoming increasingly urgent (Maswanto *et al.*, 2024). In the port a wide range of skills and competencies are necessary to support efficient and safe port operations quality (Sirajuddin *et al.* 2025). While the volume of global trade goes up, the demand for an increasing workforce knowledgeable about advanced technology, safety procedures, and the ability to adapt to digitalized systems is also happening (Sirajuddin *et al.* 2025). Modern ports become more efficient when technical skills, such as the operation of automated equipment and the understanding of digital technologies, are implemented in the operational processes (International Labour Organization, 2021; Moros-Daza & Jubiz-Díaz, 2024). If ports that adopt new technologies namely automated vehicles and big data-driven management systems, trained workers are going to be

necessary to operate those systems (Lin *et al.*, 2024). It is important to prioritize the training of human resources when introducing digitalization programs to get the benefits of digitalization (Kaburu, 2022). The collaboration with stakeholders and with other Ports that are more digitalized can be beneficial to Ports in Africa (Kaburu, 2022).

Going now for the main digital platforms on ICT Infrastructure that are Maritime Single Window (MSW) and Port Community System (PCS).

“A PCS is a trusted and neutral public-private data collaboration platform that facilitates and optimizes inter- and intra-organizational business processes among maritime supply chain stakeholders through a single submission of data” (SSATP, 2025). The PCS could be used in one specific port, but to gather the status of a single window, it needs to be connected to all ports in Africa and be supported by a legal framework (SSATP, 2025). According to Srour *et al.* (2008), PCS can be defined as a geographically grounded information hubs in global supply chains with the interest of a heterogeneous collection of port-related companies. Leonardi and Treem (2012) refer to PCS as open electronic platforms which enable the secure exchange of information between public and private stakeholders to improve efficiency and competitiveness. Maritime Single Window (MSW) enables the perfect electronic exchange of information necessary on the arrival, stay, and departure of ships in ports between public and private stakeholders (SSATP, 2025). The principal objective of MSW is to help ship clearance processes in ports for ships on international voyages (SSATP, 2025).

It is possible to minimize the corruption and reduce delays with the adoption of the Port Community System because they bring smoother trade flows (Miller & Hyodo, 2022; Umbelino de Souza *et al.*, 2021). In Africa challenges such as bureaucratic inefficiencies and limited infrastructure are predominant so PCS could bring more stability (Almeida & Okon, 2025).

In South Africa's ports, port users and stakeholders operate on different technology platforms, which does not allow for the seamless and efficient flow of cargo-related information (De Borger & De Bruyne, 2011). And as a result, several duplications happen resulting in the wastage of valuable resources, time and money (Aydogdu & Aksoy, 2015). Port users in the port system operate on different systems with their customers, creating more handover points (Mthembu & Chasomeris, 2022). Therefore, it is important

that a single window of information and communication to be implemented with the objective of smother information sharing to increase port competitiveness (Chamber of Commerce and Industry of Western Australia, 2014).

2.4 Cybersecurity as an Emerging Challenge

“With increased reliance on digitally enabled processes, supporting systems and infrastructure, the importance and focus on cybersecurity and resilience also grow in significance with cybersecurity awareness policy and training for staff” (SSATP, 2024).

In Africa, cybersecurity awareness, preparedness, and managing data safely are usually frail (SSATP, 2024). Dedicated trained workers aren’t easy to find, especially related to cybersecurity (SSATP, 2024). Giving practical training and software toolkits to enable improved cybersecurity adoption at ports and at the same time promoting guidelines is essential (SSATP, 2024). It is equally important to provide the knowledge and skills required to the workers/port staff (SSATP, 2024).

There is a higher probability of a cyberattack occurring due to digitalization (Kosiek *et al.*, 2021) and in 2020, cyberattacks in the maritime supply chain increased by 400 percent (Alamoush *et al.*, 2021). In July 2021, a cyber-attack on Transnet National Port Authority’s systems paralyzed the operations in four ports in South Africa, the ports of Cape Town, Ngqura, Port Elizabeth and Durban (Kaburu, 2022). The 2021 Annual report of the Maritime Transportation System information sharing and analysis center (MTS-ISAC), showed that attacks at operational technology systems in ports increased by 900% over the past three years (MTS, 2021). (Kaburu, 2022) in her dissertation concluded that even though “66% of the respondents confirmed that their Ports had cybersecurity technologies in place. The low level of response on use of cyber-security technologies is against 47% of the respondents indicating that they had experienced cyber-threats in the recent past.”

Digitalization comes with huge infrastructural costs so if those costs are not established that would make the systems more vulnerable to cyber-attacks (Kosiek *et al.*, 2021). The Notpetya malware attack, cost Maersk \$250 million loss in 2018 (Carballo Piñeiro *et al.*, 2021) and in 2020, cyberattacks in the maritime industry increased by 400 percent (Alamoush *et al.*, 2021). It is necessary to prioritize cybersecurity measures thinking about the huge ramifications that could happen (Caponi & Belmont, 2014).

To assist ports in cyberattacks, the International Association of Ports and Harbours (IAPH) launched its cybersecurity guidelines (Kaburu, 2022). The development of these guidelines was made regarding the concerns of stakeholders about the increased cyber threats over the past four years (Kaburu, 2022). The guidelines will help top level managers assess their level of preparedness to prevent and recover from cyber-attacks, never forgetting that no port is fully immune to those attacks (Kaburu, 2022). Moreover, the primary aim of a cybersecurity risk assessment is for the port to understand the main risks that come from the operations (IAPHCSG, 2021).

Training is another way to improve a system's utilization, while increasing users' level of awareness about cyber-security issues thus reducing risk of exposure to those issues (Kaburu, 2022). Employing reliable internet service providers and making significant investments in cyber-security along with conducting frequent vulnerability assessments will address these causes of intermittent connectivity issues and address cyber-threats respectively (Kaburu, 2022). The goal is to provide cyber-security awareness and education to all users of the internet, enabling them to safely maneuver through the internet while reducing their overall exposure (Kaburu, 2022).

With the digitalization of ports, cybersecurity becomes crucial to ensure continuity and trust (Chaula, 2025). Cyber-attacks could paralyze operations, causing delays and financial problems (Chaula, 2025). Studies highlighted the need for security and staff training to protect the port operations (Karli et, 2021; Karas, 2022). Digital adoption must be joined by solid security measures (Chaula, 2025). Cyber threats could cause severe disruptions and with the investment in cybersecurity the protection of data integrity and continuity of operations would be possible (Karli *et al*, 2021). Cybersecurity issues in the port industry are happening due to digital transformation (Zarzuelo, 2021). And the role of IoT and big data is decreasing the number of cybercrimes (Ben Farah *et al*. 2022).

Using digital applications and technologies makes not only the user to be capable and familiar with those digital innovations but also to have secure systems to protect the company and systems from cyber-attacks (Schweer & Sahl, 2016). The topic of cyberattacks and data misuse is also important to consider (Segercrantz, 2016), as there is consensus that digitization improves cybersecurity (Binder, 2016) and needs a legal framework (Fabarius, 2017).

The increase in digitization between ships, shipping companies, port companies, increases the risk of cyberattacks for all stakeholders involved (Fruth & Teuteberg, 2017). Therefore, all players in the maritime supply chain will have to ensure the best possible protection to cyberattacks, investing in future development as well as in IT security systems (Segercrantz, 2016).

2.5 Barriers for Digitalization

The digitalization process is an institutional human resource one and not just a technological issue (IAPH, 2020). Trujillo *et al.* (2013) said that some countries made robust frameworks that facilitate investment and encourage public-private partnerships. Other members' governments are weak, corrupt, and inefficient, which makes them less attractive to investors, so these nations are lacking any kind of serious development of their ports (Almeida & Okon, 2025). Political stability, economic policies, and political institutions differ greatly throughout Africa, and this makes for significant differences in how ports are governed across the continent (Almeida & Okon, 2025). In addition to this diversity created by different levels of government, socio-economic environments surrounding the ports also add to the diversity of the ports in Africa (Almeida & Okon, 2025). Some of the ports function as important entry points for well-developed urban centers that have strong established supply chains connecting them to other markets (Almeida & Okon, 2025). Ports in less developed regions could face significant challenges such as poverty, access to financing and workforce skills (Mlambo, 2021). These socio-economic factors influence the role of ports in national economies, growing their potential for growth and development (Almeida & Okon, 2025).

Other barriers found in the (SSATP, 2024) were data sharing. If partners have a negative attitude toward data sharing, reduced real-time visibility and collaboration within the supply chain can happen (SSATP, 2024). Other two barriers were if public authorities view digitalization as a barrier, it can cause delays in port digitalization and the absence of regulations for the use of digital trade platforms (SSATP, 2024).

Some issues, such as port congestion and inefficient customs processes, lead to some delays and bigger costs (Amakali, 2017; Gumede & Chasomeris 2013). According to Ayesu and Boateng (2024), outdated infrastructure and inefficient customs procedures contribute to delays and costs for shippers across Africa. Infrastructure capacity is a

critical limitation because many African ports don't have the physical and technological foundations to support advanced digital systems (Sahoo *et al.* 2024).

The dissertation "The impact of the digital maturity level on port operations in Africa" similarly found that multi-stakeholder collaboration and legal frameworks were among the barriers rated as "highly challenging" during digitalization initiatives. (Brunila *et al.* 2021) highlighted stakeholder coordination as one obstacle to port digitalization. The collaboration between stakeholders to ensure interoperability and the efficient exchange of information requires the implementation of efficient digital systems (Almeida, 2023). The inefficiency of the technological infrastructure is another weak point found by (Tijan *et al.* 2021). The collaboration with important stakeholders would be beneficial to Ports in Africa (Kaburu, 2022).

(Sakita *et al.* 2024), identified five major impediments to port digitalization in Africa: system ownership issues, sabotage and corruption, human dependence, cultural constraints, and political influence.

2.6 Governance and Public and Private Collaboration

Corruption and the quality of governance are increasingly receiving attention as they have an important impact on the performance of ports (Rodríguez *et al.* 2025). Several authors have indicated that port quality, productivity, investment decision-making, and efficiency scores are significantly affected by corruption index levels (Sequeira and Djankov, 2010; Suárez-Alemán *et al.*, 2016; Serebrisky *et al.*, 2016). Researchers who have conducted comparable studies in Latin America have found that systemic corruption raises shipping costs, reduces competitiveness, and limits container utilization (Seabra *et al.*, 2016).

Recent research has also indicated that governance and political influences are important to the operational efficiency of ports (Rodríguez *et al.* 2025). In this regard, Mlambo (2021) found that high levels of operational efficiency strongly support international trade relationships, indicating that governance, efficiency, and trade competitiveness are interconnected. Additionally, (Buor, 2024) identified national pride and political motives as major factors affecting overall efficiency, confirming that regulatory and governmental issues are essential to a combined analytic framework.

According to analysis conducted by Wanke and Barros (2015), partnership with private terminal operators in the Americas resulted in significantly enhanced coordination between the participating partners, enhancements of technological application and an increase in connectivity leading to improved overall efficiency levels. Subsequent work conducted by Wanke and Barros (2016) confirm their earlier findings and reinforce the benefits provided by connectivity infrastructure and greater use of private in managing port operations (including reduced costs and reduced delays associated with queuing).

Bagal (2008) characterizes public-private partnerships (PPP) as cooperative arrangements between both private sector entities and public sector organizations for the provision of infrastructure services and products to the public, where all participating organizations share in the responsibilities and duties associated with infrastructure service delivery (including financial inputs, profits earned, and risk assumed). According to Francoz (2010), a public-private partnership (PPP) may be defined as a collaborative business effort by both the public and private sectors whereby businesses at large deliver an assortment of services that traditionally have been provided by local government agencies and accept a considerable transfer of risk in exchange for remuneration for those risks assumed. According to Manuel (2012), a PPP is an innovative business approach that makes effective use of the required expertise from qualified pools of labor and necessary resources from the private sector to combine resources to provide optimal service delivery and thus allow government to concentrate principally on the regulatory functions that it is responsible for performing.

2.7 Conceptual Framework

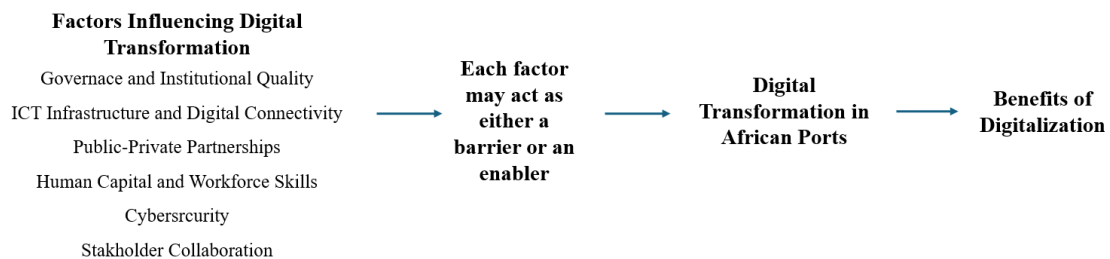


Figure 1. Conceptual Framework.

3. RESEARCH METHODOLOGY

3.1 Research Design

With this study I decided to adopt a qualitative comparative case study approach to examine the barriers, enablers and benefits influencing the digital transformation in African Ports. To be more precise after the study of digitalization in Africa, I decided to select two ports from Africa and two from Portugal and make a comparison between them. The qualitative approach was selected because the study looks to explore technological, governance, and human factors shaping digitalization processes within the African and Portuguese maritime sector and the research aims to understand how different structural conditions influence the implementation and outcomes of digital transformation initiatives in ports.

A comparative case study design was considered the most right methodological approach because digitalization levels differ significantly across African ports, while some ports have successfully implemented advanced digital systems others continue to face severe infrastructural, institutional, and governance constraints. Comparing ports with diverse levels of digitalization allows this study to name key barriers, and critical enabling factors influencing digital transformation across the continent. And with the benefit of having primary information from Porto de Lisboa e Porto de Setúbal to be able to compare them.

The ports from Africa were selected purposively because they give contrasting examples of digital transformation within the African maritime sector. The Port of Mombasa is an intermediate port, and the Port of Banjul is a lower digital maturity case characterized by infrastructural limitations, weak system integration and congestion challenges. Porto de Lisboa e Porto de Setúbal with great levels of digitalization were selected to be able to compare the African Ports with these two mentioned above.

3.2 Research Approach

The study uses a qualitative design with an abductive approach, it is proper because the research looks to understand how institutional structures, governance systems, stakeholder relationships, and organizational conditions shape the digital transformation process within African ports. “In the abductive approach, data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual

framework and test this through subsequent data collection and so forth” (Saunders, 2016). “Abductive theory development is therefore open and sensitive to data while also using pre-existing theories for inspiration and to help identify and interpret patterns”. (Saunders, 2016).

3.3 Data Collection Methods

This study uses both secondary and primary qualitative data collection methods to provide a broader understanding of the barriers, enablers and benefits influencing digital transformation in ports, this secondary data was considered appropriate because of the available academic literature related to digitalization in African ports. The data used in this study was collected from academic journal articles, reports from international organizations such as SSATP and existing case studies related to African port modernization. The study also incorporates data from previously published research papers focusing on digitalization, cybersecurity and governance within African maritime systems. The reliance on secondary data may limit the depth of analysis, however, the use of multiple reputable sources enhances the reliability and validity of the findings (Saunders, 2016). The study also incorporates primary qualitative data obtained through a semi-structured interview conducted with Vítor Caldeirinha, The president from Porto de Lisboa and Porto de Setúbal. The interview aims to offer practical insights about the barriers, enablers, and benefits associated with digital transformation in ports.

3.4 Data Analysis

Table 1. Dimensions from Literature.

Governance and Institutional Quality	Human Capital and Workforce Skills
ICT Infrastructure and Digital Connectivity	Cybersecurity
Public-Private Partnerships	Stakeholder Collaboration

The interview transcript was imported into MaxQDA and analyzed using a deductive thematic coding approach. Following the importation of the interview transcript into MaxQDA, an initial coding process was conducted to identify recurring concepts related to digital transformation in ports. A total of 21 codes were established from the interview

data. These codes were subsequently grouped in categories and then into seven broader empirical dimensions based on conceptual similarity and thematic relationships. The seven empirical dimensions found were: Strategic Governance and Institutional Support, Digital Ecosystem and Technological Integration, Organizational Adaptation and Digital Competencies, Collaborative Port Ecosystems, Investment and Innovation Capacity, Cyber Resilience and Security Management, and Operational and Strategic Benefits of Digitalization.

4. ANALYSES AND DISCUSSION OF RESULTS

4.1 Interview Findings from Porto de Lisboa and Setúbal and Comparison with Mombasa and Banjul Port

The interview data was analyzed using MaxQDA, a professional software program that enables the analysis of qualitative data and then analyzed using a thematic coding approach. Initially, individual codes were assigned to interview excerpts reflecting specific themes and concepts. Subsequently, related codes were grouped into broader analytical categories representing the main dimensions emerging from the data. The following sections present the findings obtained from the interview with the President of the Ports of Lisboa and Setúbal and compare them with the Ports of Mombasa and Banjul.



Figure 2. Word cloud of the first-order codes identified during the thematic analysis of the interview in MaxQDA. Word size represents the frequency with which each code was applied.

4.1.1 Strategic Governance and Institutional Support

During the MaxQDA analysis four main codes were found, strategic leadership, institutional coordination, policy support, and decision-making processes, then these codes were categorized as Governance Processes. In the end the dimension chosen to support these codes was Strategic Governance and Institutional Support. This dimension can be considered as an important one because several interview excerpts were coded under this category. The diverse moments the codes were found revealed that governance plays a fundamental role in shaping the success of digital transformation in ports. The interview data showed that digitalization is not merely a technological process but also an organizational and institutional transformation requiring strategic direction and stakeholder coordination.

Caldeirinha during the interview said that “one of the main responsibilities of port leadership is to define strategic objectives and ensure that technological investments are aligned with broader organizational goals.” According to Caldeirinha, “digital transformation must be integrated into the overall development strategy of the port rather than being treated as an isolated technological initiative.” During the interview he also highlighted the importance of coordinating relationships with government institutions, regulators, municipalities, terminal operators, and other stakeholders involved in port activities showing that successful digitalization depends on effective governance structures capable of aligning multiple actors around common objectives. The analysis also revealed the importance of institutional coordination in supporting digital transformation. Caldeirinha explained that “digital systems increasingly require collaboration between public authorities, customs administrations, logistics operators, shipping companies, and port authorities.” And with that governance mechanisms must facilitate cooperation and information sharing across organizations because in port environments operations involve multiple stakeholders with different responsibilities and interests. During the interview he also underlined that leadership and institutional coordination are essential for ensuring that digital systems are adopted consistently and contribute to operational improvements across the entire logistics chain.

Another important theme identified through the coding process was policy and decision-making support. Caldeirinha noted that government policies and institutional

frameworks have played a key role in accelerating digital transformation in Portuguese ports. National initiatives and European Union policies promoting digitalization, interoperability, and administrative simplification have created favourable conditions for technological investment and innovation. Caldeirinha also referred to the importance of strategic programs and policy initiatives that support digital modernization and encourage the adoption of integrated digital platforms since government support contributes not only through direct funding but also by providing a clear strategic direction and regulatory framework for digital transformation.

The comparison with the Port of Mombasa further reinforces these matters. Mombasa has strong governmental support with initiatives like Kenya's National Digital Master Plan and the implementation of the e-Citizen platform. With these policies the integration of customs procedures, electronic payment systems, and cargo management processes is easier and more intuitive. In order to accelerate digital transformation and improve operational performance in the port the government needs to be open to trade facilitation and digital governance, but governance challenges remain substantial particularly regarding coordination among different agencies and the implementation of consistent digital policies.

On the other hand, the literature reviewed for this study related to Port of Banjul identified institutional fragmentation and lack of stakeholder coordination as significant barriers presenting a less favourable governance environment in the end. In previous studies of African Ports congestion, insufficient coordination of port services, weaknesses in monitoring and regulation were also highlighted as major operational challenges. These governance-related constraints limit the effectiveness of digital initiatives and reduce the ability of the port to achieve the full benefits of modernization efforts. Comparing these four ports a suggestion comes to mind where governance acts both as an enabler and a barrier depending on the institutional context. Ports characterized by strong leadership and supportive policy frameworks will usually be in a better position to implement digital technologies successfully but ports facing institutional fragmentation, weak coordination, and inconsistent policy implementation experience greater difficulties in translating technological investments into operational improvements.

4.1.2 Digital Ecosystem and Technological Integration

Digital Ecosystem and Technological Integration were one of the dimensions analysed during the MaxQDA analysis of the interview conducted with Vítor Caldeirinha. This dimension encompasses the technological foundations required to support digital transformation, including digital platforms, integrated information systems, connectivity, data exchange mechanisms, technological innovation, and infrastructure readiness. The coding process revealed that the availability of reliable technological infrastructure is considered a prerequisite for the successful implementation of digital initiatives and the modernization of port operations.

According to Caldeirinha, “Porto de Lisboa and Porto de Setúbal currently operate a wide range of digital systems, including the Janela Única Logística (JUL), vessel traffic management systems (VTS), electronic invoicing solutions, operational monitoring tools, and digital document management platforms.” These technologies support communication between port authorities, customs administrations, shipping companies, terminal operators, and logistics providers, enabling the exchange of information in a more efficient and coordinated manner. Furthermore, digital systems are integrated throughout the logistics process, demonstrating an advanced level of digital maturity within the Portuguese port sector.

One of the codes identified during the coding process was the importance of connectivity and data exchange. Caldeirinha emphasized that “modern ports increasingly depend on the continuous flow of information among multiple actors operating within complex logistics networks.” When the workers can exchange data in real time, it translates into an enhancement in operational coordination, reducing administrative delays, and improving decision-making processes. With that, the Janela Única Logística was underlined as a critical tool for integrating stakeholders and ensuring that information is available throughout the logistics chain. The analysis also revealed that technological innovation remains a continuous process rather than a completed objective. Although the Portuguese ports have already achieved a relatively advanced level of digitalization, Caldeirinha identified several areas for future development, including “artificial intelligence, advanced data analytics, automation, and smart port solutions.” This observation highlights the dynamic nature of digital transformation and suggests that

technological readiness must be understood as an ongoing process of adaptation and innovation.

Analysing the situation of the port of Mombasa, we observe the implementation of several digital initiatives, including electronic customs clearance systems, digital payment platforms, cargo tracking technologies, and integrated information management systems in recent years, giving the port better transparency, facilitation in information exchange, and better operational coordination among stakeholders. However, Mombasa continues to face infrastructure-related challenges like system interoperability. The case therefore demonstrates that digital technologies can generate substantial improvements but cannot entirely compensate for broader infrastructure limitations. The situation observed in the Port of Banjul differs considerably, since previous studies identified inadequate infrastructure, limited internet connectivity, insufficient berth facilities, and outdated handling equipment as major constraints affecting port performance. Organizational challenges were further compounded by insufficient information system integration and limited synchronization with other ports. These conditions create significant obstacles to the implementation of advanced digital technologies and reduce the capacity of the port to benefit fully from digital transformation initiatives.

Comparing these four ports a clear relationship between technological readiness and digital transformation outcomes showed that ports characterized by reliable digital infrastructure, integrated information systems, and strong connectivity generally demonstrate higher levels of digital maturity and operational performance. Instead, ports facing infrastructure deficiencies encounter bigger difficulties in implementing and sustaining digital initiatives.

4.1.3 Organizational Adaptation and Digital Competencies

The coding in MaxQDA revealed that technological transformation within ports is linked to the ability of employees and organizations to adapt to new ways of working. Three main codes were identified within this dimension: digital skills and training, workforce adaptation to technological change, and organizational resistance to innovation.

The interview data indicate that technological investments alone are insufficient to generate meaningful improvements if employees cannot use new systems effectively.

Caldeirinha showed the importance of workforce training and digital literacy, arguing that “technology only creates value when people possess the necessary skills to operate, manage, and optimize digital solutions.” Training was described as a critical component of the digitalization process, contributing not only to technical competence but also to greater confidence in the use of innovative technologies. According to the interviewee, “continuous learning has become increasingly important as ports adopt more sophisticated digital platforms and information systems.”

In the interview Calderinha pointed out that digital transformation often requires substantial modifications to established working practices and operational routines, displaying the code workforce adaptation to technological change that was found during the MaxQDA analysis. With ports becoming more digitalized, employees are expected to interact with new systems, manage larger volumes of information, and adapt to more integrated operational environments yet these changes require not only technical skills but also organizational flexibility and a willingness to embrace new approaches to work, so the support to employees is necessary. The analysis also revealed the existence of organizational resistance to innovation as a potential challenge. According to Caldeirinha, “many of the obstacles associated with digital transformation are not necessarily technological but rather related to organizational culture and resistance to change.” Workers that don’t have the right knowledge about these technologies are hesitant to adopt unfamiliar systems, particularly when digitalization replaces established procedures or introduces new responsibilities. Resistance to change can slow implementation processes and reduce the effectiveness of technological investments. Caldeirinha identifies leadership, communication, and employee engagement as important mechanisms for reducing resistance and encouraging acceptance of modern technologies.

Analysing the cases of African ports, the Port of Mombasa, show that digital transformation initiatives have required significant workforce adaptation as electronic customs systems, digital payment platforms, and integrated cargo management solutions, which became increasingly embedded within port operations. Digitalization contributed to improvements in efficiency and coordination. The transition process required substantial organizational adaptation and ongoing capacity development, yet workers and stakeholders were required to become familiar with new technologies and administrative

procedures so as to maximize the benefits of these systems. Nevertheless, previous studies showed that limited digital literacy, skills shortages, and insufficient training opportunities are important constraints affecting modernization efforts in Banjul and showing that organizational challenges are compounded by resource limitations and the absence of comprehensive workforce development programs. So, the ability of employees to adapt to technological change remains more restricted, reducing the effectiveness of digital initiatives and slowing the pace of digital transformation.

4.1.4 Collaborative Port Ecosystems

The three main codes of this chapter are information sharing and interoperability, coordination among stakeholders and collaborative decision-making, these codes were aligned in the MaxQDA platform and organized as a category with the name Stakeholder Coordination. Although digital technologies are often associated with software automation, and data management, the interview accentuated that their real value lies in their ability to connect organizations and facilitate communication. In this regard, digital transformation was repeatedly described not as an isolated technological process, but as a mechanism that enables cooperation among stakeholders who traditionally operate within different organizational environments.

Caldeirinha said that “Currently, there is much faster and more efficient information sharing among port authorities, customs, operators, shipowners, shipping agents, and carriers within the JUL.” As ports become more connected to global supply chains, having an ability to share information quickly and accurately is also becoming critical to achieving operational efficiency. Digital Platforms such as the Janela Única Logística help facilitate this process by providing a common digital platform to enable stakeholders to access and exchange information with one another. Rather than relying on separate communications mechanisms or paper documentation, users today can use integrated systems that are designed to improve visibility and coordination of all activities occurring at the port. One repeated theme from the interview was that digitalization adds value by improving the speed of information exchange between organizations. This enhanced speed enables users to coordinate their activities more effectively, prepare for potential operational issues and make decisions based upon real time operational data. Caldeirinha also indicated that there has been a significant improvement in the efficiency of sharing information as opposed to previous times, which has allowed for greater transparency and

less duplication of efforts. Furthermore, users have benefited not only by simplifying administrative tasks but have also been able to develop stronger relationships amongst all the different entities working within the port.

Collaborative decision making was also recognized as being significant. Due to the nature of port operations, multiple independent organizations are involved with port operations, therefore, any decisions made by one stakeholder will impact the level of performance achieved by another stakeholder through a port. Digital systems enable stakeholders to have access to shared data and information, thereby permitting their coordinated actions enabling stakeholders to respond more effectively to challenges associated with operating in a port environment. In Caldeirinha's view, "having access to common digital platforms has enabled significantly more rapid decision-making processes and improved operational planning." If a logistics chain has increasing complexity and increases in customer demand for rapidness and reliability, then the emphasis on collaborative decision-making will continue to grow.

The importance of working together with stakeholders is also evident in the African cases. At Mombasa Port, customs officials, shipping lines, and terminal operators have made great strides together using a variety of e-platforms to achieve their goal. There is now a system of digital customs procedures, e-payment solutions, cargo management systems and the implementation of the MSW at Mombasa Port that allows for improved communication among stakeholders and more efficient transfer of information throughout the port environment. The implementation of these systems has helped to reduce the amount of time needed to process shipments, thus demonstrating that cooperation between stakeholders is necessary to improve the outcomes of digital initiatives. Previous research has shown that the lack of coordination between the various types of seaport services and the limited integration of information technology systems at the Port of Banjul are two major issues impacting the operations at the port. Many of the stakeholders at Banjul Port are still working in "silos," which limits their ability to work together to make collective decisions about how to best deliver their services. As a result, digital initiatives will likely continue to face challenges because the potential value of digital technologies is not achievable if the stakeholders are unable or unwilling to communicate and coordinate with each other. Working together with stakeholders is not only a byproduct of digital initiatives but is also one of the main features of those

initiatives because digital technologies can improve communication and the flow of information. However, they require the participation of all the stakeholders involved in order to be successful. The ports where there is more interaction between the stakeholders seem better placed to reap benefits of digitization compared to ports that exhibit fragmented structures with little coordination among the players.

4.1.5 Investment and Innovation Capacity

Caldeirinha discussed technology, governance, and stakeholder collaboration and many of these observations were linked to the availability of financial resources and the ability of organizations to invest in innovation. As a result, several coded excerpts relating to investment capacity, technological innovation, and operational efficiency were grouped under this dimension.

A major point made in the interview is that ongoing investment in digital transformation is necessary, rather than individual technological projects. Caldeirinha described that “ports operate in an environment characterized by rapid technological change, requiring constant updates to digital systems, infrastructure, and operational processes.” The ability to retain digital competitiveness requires allocation of sufficient resources to not only implement new technologies, but also to maintain, upgrade and integrate those technologies into existing operational environments. As such, digitalization is a long-term strategic investment rather than being a one-off modernization of that port's operations. Additionally, the interview identified that stable funding mechanisms are critical to support innovation. The financial resource base was necessary to acquire digital technologies, modernize existing infrastructure, train personnel and develop cybersecurity capabilities. Caldeirinha explained that the “Ports of Lisboa and Setúbal have benefited from a combination of institutional support, European funding programs, and internal financial resources, but sometimes the lack of fundings is a reality.” This diversity of funding sources has allowed ports to pursue their modernization projects, while taking into consideration the long-term technological development. However, the interviewee did recognize that digital transformation is still an expensive endeavor, and there will always need to be a financial commitment for this to succeed.

Based on analysis of data from the MaxQDA program, another major outcome reveals a key relationship between innovation and operational performance through technological innovation as identified in the interview. The interviewee linked technological innovations with efficiency improvements, better service quality and improved competitiveness of their organization. Digital systems were presented as tools to help organizations reduce their administrative burden, better manage information and support faster operational processes. However, the interviewee did not feel that the benefits from technology would automatically be realized just because the organization had adopted them, so organizations need to have the right financial and managerial capabilities in place to enable them to turn their technological investments into operational improvements. In Caldeirinha's words, "innovation creates value when it is supported by appropriate investment strategies and organizational commitment."

In Mombasa, Africa, the port has seen significant modernization throughout the last few years as a result of massive investment in digital customs, electronic payments, cargo tracking and integrated information systems. This modernization has improved transparency, operational coordination and trade facilitation in the port. However, as noted in the case of Banjul, the lack of financial investment was one of the primary barriers to modernizing and adopting technology. Because of limited funding for investment, the ability to acquire new technology and make improvements to infrastructure as well as the opportunities for workforce are restricted. Therefore, the digital transformation process is slow to grow, and it makes it harder to receive the possible benefits from digital transformation. This is an example of how financial restraints have an impact not only on the ability to adopt new technology but also on the overall ability of a port to pursue long-term innovation strategies. Additionally, the interview pointed out the importance of public-private partnerships in driving technological advancements. According to Caldeirinha, "Public-private partnerships play a significant role in port modernization." They enable the combination of resources, technical expertise, and innovation capacity. Many technological investments are carried out by private operators in close collaboration with port authorities. This collaborative approach provides for new innovative ideas while also decreasing the amount of financial strain on organizations implementing digital transformation solutions.

Ports that have sufficient access to financial resources and solid innovation ecosystems seem to be leading the way in advancing or adopting technology compared to ports that have limited financial resources or limited access to the innovation ecosystem. Conversely, financial restraint limits technological advancement and, therefore, limits the benefits that can be received from digitalization.

4.1.6 Cyber Resilience and Security Management

As port authorities' reliance on digital technologies increases, the way cybersecurity is viewed has shifted from being strictly a technology issue to now being viewed as a strategic management issue. The interconnectedness between digital transformation and cybersecurity was evident in the interview, particularly when it came to how digital systems are being used to create efficiencies, improve transparency and increase coordination vs. the fact that the increased use of digital systems creates additional opportunities for cyber threats that could disrupt operations and impact entire logistics chains. This connection was also evident in the MaxQDA analysis, as numerous coded excerpts referenced cyber risk awareness, operational resilience, and cybersecurity preparedness.

One of Caldeirinha's statements indicated that he regards cybersecurity to be one of the top priorities of modern-day ports. "As more operational activities become dependent on interconnected digital systems, the potential consequences of a cyber incident become increasingly significant." The operations of ports today are reliant on digital systems to manage vessel traffic, process cargo, share information, and communicate with stakeholders. Any interruption of these digital systems could not only impact on the port itself, but also on an entire supply chain and therefore is seen as a strategic priority and not just a technology issue.

One interesting point raised during the interview was the importance of being prepared for a cyber event rather than having strictly protective measures. The interviewee stated that "no organization can completely eliminate cyber risks." Rather, the focus should be on ensuring that Ports have the capability to avoid an incident, detect the threat in a timely manner, and respond to the event when it occurs. This type of focus reflects the tremendous growth in the significance of operational resilience as we continue to live in an increasing digital world. As stated by Caldeirinha, both Ports have enhanced

their cyber defense via “continuous monitoring, the development of internal processes, preparing incident response plans, and implementing employee awareness training programs.” Although cyber security is a continual process that requires on-going adaptation to threats and vulnerabilities as they emerge, technology often plays a key role in protecting and defending digital infrastructure. The interviewee identified as critical programs for reducing human error-related vulnerabilities through awareness campaigns, training programs, and regular test exercises. Most importantly, the interviewee noted that most cyber security threats are created through the actions of users rather than a weakness in the technology used to protect the organization. Therefore, the preparedness for tackling cyber security threats consists of not only having the right technology to defend against an attack but also having employees who understand their roles and responsibilities related to creating a cyber resilient organization.

In Africa, the importance of cybersecurity is clear. One of the most widely discussed examples of this is the cyber-attack on Transnet in South Africa in 2021, the disruption created by the attack impacted on daily operations at numerous ports and resulted in long delays throughout the entire logistics supply chain. It also illustrated how susceptible modern port infrastructure could be when compromised by cyber-attacks, demonstrating the potential economic impact of cybersecurity failures. The interviewee also pointed out that Portuguese ports have been victims of prior cyber-attacks, reinforcing the notion that there are cybersecurity threats that are not limited to a specific region and rather, they are global issues for the maritime industry.

In Lisboa and Setúbal, cybersecurity is integrated into a more extensive digital transformation strategy through established procedures, training programs and institutional collaboration. Mombasa has also grown its reliance on digital systems and therefore is experiencing an increase in exposure to cyber risk. In Banjul, because of a lack of resources and lower levels of technical development, they may not have the ability to invest in advanced cyber security solutions. Regardless, continued digitalization in all regions will require increasing attention to cyber resilience if the advantages of digital transformation are to remain for the long term.

Through this research findings, it is becoming apparent that Cybersecurity is no longer seen as something which should only be considered after digital technologies have been

deployed, it should form part of the digital transformation process itself. The greater reliance that ports place upon digital systems results in operations and trust in the organization being directly related to how effectively they can manage cyber risks. Therefore, investment in technology should go together with investment in security, training and resiliency.

4.1.7 Operational and Strategic Benefits of Digitalization

The final dimension emerging from the MaxQDA analysis relates to the benefits generated by digital transformation within port environments. Throughout the interview, digitalization was consistently associated with improvements in operational performance, information management, service quality, and competitiveness. Rather than being viewed solely as a technological modernization effort, digital transformation was presented as a strategic tool capable of enhancing the overall functioning of the port ecosystem. The coded excerpts grouped under this dimension highlighted four fundamental areas of benefit: operational efficiency, transparency and information sharing, service quality and competitiveness, and decision-making support.

One of the main benefits discussed on the interview was the improvement of operational efficiency. According to Caldeirinha “the implementation of digital platforms has simplified administrative procedures and reduced dependence on manual and paper-based processes.” By completing transactions that previously involved multiple exchanges of physical documents now electronically, using digital platforms enables the elimination of delays in processing, thereby increasing operational speed. In addition, digital platforms help facilitate coordination of port activities by providing faster methods of communicating information among all parties involved. Ultimately, as operational processes are streamlined and available resources are maximized, the quality of service provided improves. Caldeirinha's interview also pointed to how digitalization has improved both transparency and information sharing. By having more digital platforms available, stakeholders can easily access operational information directly related to port operations. According to Caldeirinha, “the use of integrated systems has improved the visibility of port operations and facilitated access to relevant information.” Increased visibility allows for greater trust between the parties involved, diminishing the amount of information asymmetry as well as facilitating the identification and resolution of operational problems in a timely manner. Another benefit of digitalization mentioned in

the interview was around service quality and competitiveness. According to the interviewee, customers are demanding faster, more dependable and more transparent services from service providers. Ports can meet customer expectations through digital innovations, such as increasing responsiveness, reducing administrative burdens and facilitating communication with users. In a very competitive shipping environment, ports that provide efficient digital services will be in a much stronger position to attract shipping companies, logistics providers and cargo flows.

Digitalization also significantly influences decision-making processes through its use in generating large amounts of information pertaining to ports. As a result of modern port operations, the data generated will allow for improved planning (as it will allow for better monitoring of performance), as well as identification of areas of inefficiencies within operation. Caldeirinha highlighted that “digital systems provide workers with access to more accurate and timely information, allowing decisions to be made on the basis of real-time data rather than delayed reports or fragmented information sources.” Further, the use of digital systems has been shown to help increase operational management efficiencies and improve a port's ability to respond to varying conditions within the ever-increasing complexities of global supply chains.

Additionally, several of the positive effects that were noted during the interviewing have been seen within the African cases. The implementation of several digital initiatives at the Port of Mombasa has improved many parts of the import/export process. Improvements were seen in customs procedures, payment processes and cargo visibility. As a result of integrating electronic systems in ports, administrative processes have been streamlined to reduce the amount of paper generated and speed up administrative functions by improving communication between stakeholders. While the port of Banjul has not yet reached a similar level of digital maturity as other ports, many of the modernizing projects currently being considered or already initiated are seeking to achieve the same objectives. Digitalization has the potential to improve information sharing, reduce congestion, improve coordination of operations and improve service delivery to the Port of Banjul, provided that the frameworks currently exist in large measures. This comparative analysis suggests that while there may be differences in the level of digital maturity among ports, the expected outcomes of digital transformation by technology will virtually all be the same.

An interesting observation emerging from the findings is that the benefits of digitalization are closely interconnected. Improvements in information sharing contribute to better decision-making, better decision-making enhances operational efficiency, and increased efficiency improves service quality and competitiveness. Consequently, digital transformation generates value not through isolated technological interventions but through the cumulative effects of multiple improvements across different areas of port activity.

4.2 Cross-Case Analysis

Table 2. Cross-Case Analysis.

Empirical Dimension	Strategic Governance and Institutional Support	Digital Ecosystem and Technological Integration	Organizational Adaptation and Digital Competencies	Collaborative Port Ecosystems	Investment and Innovation Capacity	Cyber Resilience and Security Management	Operational and Strategic Benefits of Digitalization
Porto de Lisboa e Setúbal	Strong strategic leadership, clear digital vision, and institutional coordination.	Advanced digital systems, integrated platforms, and reliable connectivity.	training and workforce adaptation programmes.	Strong stakeholder coordination supported by integrated platforms.	Strong financial resources and innovation programmes	Cybersecurity embedded within digital strategies and operational procedures.	Significant improvements in efficiency, transparency, service quality, and competitiveness.
Port of Mombasa	Government support through digital trade facilitation policies, although coordination challenges remain.	Significant digital investments, although infrastructure bottlenecks persist.	Ongoing workforce adaptation supported by digital reforms.	Improved collaboration through electronic customs and digital systems.	Significant investments in modernization and digitalization.	Growing awareness of cyber risks, although vulnerabilities remain.	Enhanced trade facilitation, cargo visibility, and operational performance.
Port of Banjul	Weak institutional coordination and governance constraints.	Limited ICT infrastructure and weak system integration.	Skills shortages and limited digital literacy remain significant challenges.	Limited interoperability and fragmented coordination.	Financial constraints limit technological investment.	Limited cybersecurity preparedness and capabilities.	Benefits recognized but only partially realized due to persistent barriers.
Cross-Case Analysis	Governance emerged as a critical determinant of digital transformation. Ports with stronger institutional support demonstrated higher levels of digital maturity and implementation success.	Infrastructure readiness strongly influences digitalization outcomes. Digital transformation progresses more rapidly where reliable technological infrastructure exists.	Human capital was identified as a common factor across all cases. Successful digitalization requires both technological investment and workforce development.	Stakeholder collaboration enhances the effectiveness of digital systems. Ports with stronger information-sharing mechanisms achieve greater operational benefits.	Investment capacity directly affects the pace and scope of digital transformation. Resource limitations remain a major challenge in less developed ports.	Cybersecurity maturity generally stays behind digitalization. As digital dependence increases, cyber resilience becomes increasingly important for all ports.	The benefits of digitalization are similar across all ports; however, the extent to which these benefits are realized depends on the availability of enabling conditions.

4.3 Discussion of Findings

The objective of this chapter is to discuss the empirical findings presented in the previous sections and compare them with the literature reviewed in Chapter 2 and respective dimensions. The analysis sought to understand whether the barriers, enablers, and benefits identified through the interview and case studies are consistent with previous research on port digitalization and digital transformation in Africa. Overall, the findings strongly support the conceptual framework developed for this dissertation because the dimensions identified through the MaxQDA analysis are closely aligned with the factors identified in the literature as influencing digital transformation outcomes within ports.

A major finding of this study was the critical role that governance and institutional support play in enabling successful digital transformations and digitalization. The Caldeirinha's interview revealed the critical significance of leadership, strategic planning and stakeholder coordination for enabling successful digital transformation efforts. The findings are consistent with (Rodríguez *et al.* 2025) that indicated that governance and political influences are important to the operational efficiency of ports, also Mlambo (2021) that found that high levels of operational efficiency strongly support international trade relationships, indicating that governance, efficiency, and trade competitiveness are interconnected. Similarly, Buor (2024) identified national pride and political motives as major factors affecting overall efficiency, confirming that regulatory and governmental issues are essential to a combined analytic framework.

Similarly, the findings support the arguments of Sakita *et al.* (2024), who identified governance-related challenges such as political influence, institutional constraints, and organizational barriers as major impediments to digital transformation. Mombasa's strong digital trade facilitation initiatives and the role of government support, as demonstrated by its comparison with Banjul, that the provision of quality governance is an important element in developing a digital economy.

The importance of technological readiness and infrastructure availability as a prerequisite for successful digital transformation is confirmed, because during the interview the role of integrated digital platforms, information systems, and reliable connectivity in supporting efficient port operations was emphasized. These observations are consistent with the work of Sahoo *et al.* (2024), who argued that infrastructure is a critical limitation affecting African ports. Similarly, the findings support the conclusions of Tijan *et al.* (2021), who identified technological infrastructure deficiencies as significant barrier to digitalization. Strong digital infrastructure at ports like Lisboa and Setúbal will usually enable these locations to implement and sustain more advanced digital solutions than other ports.

The interview revealed that workforce adaptation, digital skills, and resistance to change remain important challenges even within advanced port environments. The results support the observations of (Sirajuddin *et al.* 2025) who showed the importance of training and workforce development for digital transformation. They also align with the

analysis reported in the dissertation “The Impact of The Digital Maturity Level on Port Operations in Africa” done by Joyce Wanjiru Kaburu, where interviewees identified training limitations and organizational resistance as major barriers to digitalization. The evidence therefore suggests that digital transformation should not be viewed solely as a technological process but also as a human and organizational transformation requiring continuous learning and adaptation.

Additionally, collaboration with stakeholders was recognized as a major driver of successful digitalization. The interview findings demonstrated the role of information exchange and coordination among port stakeholders as well as identifying collaboration in the literature consistently as a necessary condition for successful digital integration. These results are different from Brunila, *et al.* (2021), that highlighted stakeholder coordination as one obstacle to port digitalization. So, if the collaboration between stakeholders is not successful, it can be a barrier, but if the collaboration is good, it could be considered an enabler. The examples from Mombasa provided evidence that an integrated digital system can enhance stakeholder cooperation, while the problems encountered in Banjul indicated operational issues due to limited coordination and fragmented information flows.

An interesting contribution of the empirical analysis concerns the emergence of investment and innovation capacity as a distinct dimension. Although many articles discuss the need for partnerships and substantial investment in infrastructure as enablers of digitalization, the interview responses indicated that a broader view of financial resources and innovation ecosystems are vital for supporting long-term digital transformation. This signifies that digitalization should not be viewed as a collection of independent technological projects but rather continuous change requiring both consistent investment and organizational commitment. In this regard, empirical evidence extends existing research by emphasizing the strategic relationship between investment capacity, innovation, and digital maturity.

In the Cybersecurity chapter the interview observations indicated that increasing digital dependence requires stronger cybersecurity measures and greater attention to operational resilience and this is consistent with the evidence presented in the dissertation “The Impact of The Digital Maturity Level on Port Operations in Africa” done by Joyce

Wanjiru Kaburu, which reported that 47% of surveyed ports had experienced cybersecurity threats despite only 66% implementing cybersecurity tools. They also support broader concerns raised in the literature regarding the vulnerability of digitalized ports to cyberattacks. The Transnet cyber-attack in 2021 illustrated how weaknesses in cybersecurity can have major impacts on port operations and on the wider logistics industry.

The results of the study also support previous studies' findings related to benefits from the digital transformation of ports. The interview material highlighted improvements in efficiency, transparency, information sharing, service quality, and decision-making. These observations from (Balci, 2021) showed that digitalization of processes and operations has had a positive impact on performance and efficiency levels and facilitated communication with different stakeholders and (Sanchez-Gonzalez *et al.*, 2022) showed that digitalization enables greater transparency. The Port of Mombasa has experienced higher operational efficiencies and enhanced facilitation of trade by electronic payment platforms and digital customs systems. While Banjul has not yet reached the same level of digital maturity, literature suggests that similar benefits to those achieved in Mombasa may occur, assuming barriers to success identified in this study are overcome.

5. CONCLUSION

This dissertation set out to investigate the barriers, enablers, and benefits associated with digital transformation in African ports. More specifically, it sought to identify the main factors influencing digitalization processes within African ports and to examine how these factors compare with the experiences of the Ports of Lisboa and Setúbal. The data demonstrate that digital transformation is influenced by a combination of interconnected factors rather than by technology alone. Governance and institutional quality, ICT infrastructure, human capital, stakeholder collaboration, public–private partnerships, and cybersecurity turn up as the most significant dimensions affecting digitalization processes across all cases analyzed. Although the importance of these dimensions was evident in both African and Portuguese ports, their impact varied according to the institutional, economic, and technological context of each port.

The findings also validate the conceptual framework developed in this dissertation. The digital transformation of ports is influenced by the intersection of governance, ICT

(information and communication technologies) infrastructure, human capital, stakeholder collaboration, public-private partnerships, and cybersecurity, as set out in the presented framework. Most of the empirical evidence gathered through the interview and case studies supports the framework, indicating that these elements are interrelated and provide mutual reinforcement. Thus, the overall conclusion is that digital transformation is a socio-technical process involving multidimensional technological and institutional transformations.

From a theoretical perspective, this dissertation contributes to the literature around digitalization of ports, as it shows that there are other factors outside of technological adoption that explain successful digital transformation. Ultimately, the study shows that governance and institutional capacity are critical to achieving successful digitalization outcomes. Some limitations were also found, the research focused on two African case studies, namely the Ports of Mombasa and Banjul, which limits the generalizability of the findings to the broader African port sector. A single semi-structured interview with Vítor Caldeirinha was the primary data collection for this research project. Although this interview provided great first-hand data, interviews with a broader range of stakeholders from other Portuguese and African ports would add value to the empirical analysis. Also, the second part of this study was based on secondary data sources for the African case studies, which means that the findings of the study have been based upon the availability and quality of literature on the African ports.

Opportunities for future research emerge from this study are that future studies could expand the number of African ports examined and include other regions to provide a broader understanding of digital transformation across the continent. Future research could incorporate primary data collection within African ports through interviews, surveys, and fieldwork involving port authorities, organization providers and terminal operators, such approaches would offer deeper insights into the practical challenges and opportunities associated with digitalization.

In conclusion, as this study demonstrates, the digital transformation of ports presents both an opportunity and a challenge for ports. The improved efficiencies, transparency, coordination and competitiveness anticipated with the increased use of digital technology will only be realized if there are sufficient institutional, organizational and technological

resources for implementing this technology and supporting the transformation of ports using digital technology. The experiences of Mombasa, Banjul, Lisboa and Setúbal have shown collectively that the digital transformation of the port will not only be a technological transformation of the port but also a transformational change within the organizational and institutional nature of the port, which will require a coordinated effort across many areas of the organization.

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7. APPENDICES

Appendix 1.

Table 3. Interview Script

Research Objectives	Interview Script	Authors
Current State of Digitalization	How would you describe the current level of digitalization within the Port of Lisbon and Port of Setúbal? Which digital technologies or systems are currently being used in the port? In your opinion, what have been the main drivers behind digital transformation in the port? How important is digitalization for improving port competitiveness and operational performance?	Kraus <i>et al.</i> (2021) & Omol (2024); (Almeida & Okon, 2025); (Dong, Liu, Tae-Woo Lee, Chi & Ye, 2023); (SSATP, 2025); Buor (2024).
Benefits of Digitalization	What benefits has digitalization brought to the Port of Lisbon and Setúbal? Has digitalization improved collaboration between stakeholders? Have digital systems contributed to increased transparency and reduction of bureaucratic inefficiencies?	(Dong, Liu, Tae-Woo Lee, Chi & Ye, 2023); (Sirajuddin <i>et al.</i> 2025); (Miller & Hyodo, 2022; Umbelino de Souza <i>et al.</i>, 2021); Mlambo (2021).
Barriers to Digital Transformation	How would you define barriers to digitalization in the port environment? What are the main barriers affecting digital transformation?	(Fraser & Notteboom 2016; Gumede & Chasomeris 2018); (Ayesu & Boateng, 2024); (Mazibuko <i>et al.</i>, 2024); (Almeida & Okon, 2025);

	To what extent do governance and administrative structures influence digitalization processes? Are there sufficient financial resources and institutional support? Do legal or regulatory frameworks facilitate or slow down innovation?	(SSATP, 2024); (Zerbino, Aloini, Dulmin & Mininno, 2019); De Borger & De Bruyne, 2011); (Aydogdu & Aksoy, 2015); Ayesu & Boateng (2024); (Brunila <i>et al.</i> 2021); Sakita <i>et al.</i> (2024).
Key Enablers of Digitalization	How would you define an enabler for digitalization? What factors have most contributed to successful digitalization initiatives? How important is government support and policy alignment? What roles do public-private partnerships play? How important is workforce training and digital literacy? Does the port collaborate with external stakeholders or international partners?	(SSATP, 2024); (Balci, 2021); (Leonard Heilig, 2017); (Sanchez-Gonzalez <i>et al.</i>, 2022); (Sirajuddin <i>et al.</i> 2025); (Maswanto <i>et al.</i>, 2024); (International Labour Organization, 2021; Moros-Daza & Jubiz-Díaz, 2024); (Lin <i>et al.</i>, 2024); Bagal (2008).
Cybersecurity and Risk Management	How significant are cybersecurity concerns? How prepared is the port to deal with cybersecurity threats? Are employees provided with cybersecurity awareness or training? Has increasing digitalization increased operational vulnerability?	(SSATP 2024); (Kosiek <i>et al.</i>, 2021); (Alamouch <i>et al.</i>, 2021); (Kaburu, 2022); (Kosiek <i>et al.</i>, 2021); (Chaula, 2025).

	What measures are currently used to protect digital infrastructure?	
Comparative Perspective	Do you believe the barriers to digitalization in African ports are similar to those faced in European ports? What are the main differences between African and European ports regarding digital transformation?	
Lose Questions	Did some cyberattack happened in Lisboa or Setúbal? Some barriers in Africa are financial, structural and governmental barriers, does it compare with Portugal? Can you say that the benefits for digitalization are identical in all Ports?	(Alamouch <i>et al.</i>, 2021); (MTS, 2021); (Kaburu, 2022); (SSATP, 2024); Ayesu & Boateng (2024); Sakita <i>et al.</i> (2024).

Appendix 2.

Table 4. Development of Empirical Dimensions from MaxQDA Coding.

Dimensions	Category	Codes
Strategic Governance and Institutional Support	Governance Processes	Strategic leadership and vision; Institutional coordination; Policy and decision-making support.
Digital Ecosystem and Technological Integration	Digital Technologies	Digital platforms and integrated systems; Connectivity and data exchange; Technological innovation; Infrastructure readiness.
Organizational Adaptation and Digital Competencies	Workforce Capabilities	Digital skills and training; Workforce adaptation to technological change; Organizational resistance to innovation.
Collaborative Port Ecosystems	Stakeholder Coordination	Information sharing and interoperability; Coordination among stakeholders; Collaborative decision-making.
Investment and Innovation Capacity	Resource Mobilization	Investment capacity; Technological innovation; Operational efficiency.
Cyber Resilience and Security Management	Cyber Resilience	Cyber risk awareness; Operational resilience; Cybersecurity preparedness.
Operational and Strategic Benefits of Digitalization	Digitalization Outcomes	Operational efficiency; Transparency and information sharing; Service quality and competitiveness; Decision-making support.

With the coding process I found 21 codes. Subsequently, conceptually related codes were grouped into broader categories, which were then consolidated into seven empirical dimensions.

Appendix 3.

Codes		87
▼ Digitalization Outcomes		1
Decision Making Support		2
Service Quality and Competitiveness		7
Transparency and Information Sharing		2
Operational Efficiency		6
▼ Governance Processes		1
Strategic Leadership and Vision		6
Institutional Coordination		4
Policy and Decision-making Support		5
▼ Digital Technologies		1
Digital Platforms and Integrated Systems		4
Connectivity and Data Exchange		5
Technological Innovation		3
Infrastructure Readiness		3
▼ Workforce Capabilities		1
Digital Skills and Training		2
Workforce Adaption to Technological Change		1
Organizational Resistance to Change		3
▼ Stakeholder Coordination		1
Information Sharing and Interoperability		3
Coordination Among Stakeholders		2
Collaborative Decision Making		3
▼ Resource Mobilization		1
Operational Efficiency		6
Technological Innovation 2		1
Investment Capacity		2
▼ Cyber Resilience		1
Cyber Risk Awareness		4
Operational Resilience		3
Cybersecurity Preparedness		3

Figure 3. Coding Structure Developed in MaxQDA.

The number 87 refers to the total number of times that the codes were found during the interview. The codes are organized in 7 categories, so the total was 80.