COMPARATIVE ANALYSIS OF PORT GOVERNANCE MODELS FOR GREEN ENERGY TRANSITION

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1. **ABSTRACT:** Since the beginning of maritime trade, Ports have consistently driven global economic and societal progress. Concerns have arisen due to the environmental impact of port operations, particularly emissions. Thus, it has become essential to highlight the recognition of the International Maritime Organization (IMO) toward ports being as pivotal in the logistics network and their ability to reduce greenhouse gas (GHG) emissions from shipping. This emphasises the importance of ports adopting measures to decrease emissions and promote sustainability, aligning with global efforts to decrease the environmental impact of maritime trade. The transformation of ports towards eco-friendly and sustainable practices represents not only an urgent imperative but also a substantial challenge characterised by numerous obstacles. In this sense, port governance can be seen as a determinant factor in moulding port strategies and tools adoption to foster environmentally responsible practices within ports and beyond.

   This article, therefore, conducts a comprehensive comparative analysis of various port governance frameworks with the aim of ascertaining the most efficacious model that can bolster the transition of ports toward greener and more sustainable operations in GHG reduction. Through an appraisal of the merits and demerits of distinct governance structures, this research endeavours to provide insights that can guide policymakers and port authorities in making the right choices concerning the revolution of environmentally conscientious and sustainable port development.

2. INTRODUCTION

Throughout history, ports are serving as key facilitators of integration into the global economic system. Notably, more than 80% of global trade is conducted through the maritime sector, emphasising ports' crucial role in international commerce (Humphreys 2023). Even landlocked countries heavily depend on the ports of neighbouring nations to facilitate trade and economic connectivity (World Bank 2014), underscoring the vital role of ports in facilitating trade and fostering economic connectivity. This dependency highlights the strategic importance of ports in the global trading network and broader economic activities.

However, because of all the different services and activities in the port area, ports negatively impact the environment. These activities affect the quality of life for nearby populations, which may directly or indirectly affect the air, water, soil, and sediment (Azarkamand, Wooldridge, and Darbra, 2020). According to the International Maritime Organization (IMO) GHG study in 2020 (IMO 2021), the proportion of shipping emissions in global emissions rose from 2.76% in 2012 to 2.89% in 2018. Additionally, the total greenhouse gas (GHG) emissions measured in CO2e from the shipping sector escalated from 977 million tons in 2012 to 1,076 million tons in 2018, marking a 9.6% increase. Nevertheless, Misra et al. (2017) indicate in their study that the port industry, on its own, contributes to 3% of the overall GHG emissions. Additionally, it is crucial to consider the activities within ports and the CO2 emissions associated with vehicles entering and leaving the port (Sugimura 2023). This underscores the substantial volume and responsibility for the environmental impact attributed to ports.

The UN Framework Convention on Climate Change (UNFCCC) ratified The Paris Agreement, establishing an ambitious framework for climate mitigation, adaptation, and financial commitments by countries (Cordonier Segger 2016). In the marine industry, the IMO adopted the GHG Strategy, emphasising a reduction in the carbon intensity of international shipping by at least 40% by 2030. In 2023, The IMO GHG Strategy introduces a heightened level of ambition, adopting zero or near-zero GHG emission technologies, fuels, and energy sources. The objective is for these alternatives to constitute a minimum of 5%, with an aspirational target of 10%, of the energy consumed by global shipping by 2030 (IMO 2023).

In this context, many ports have successfully improved air quality by implementing various intricate measures, necessitating widespread cooperation among port stakeholders (Sornn-Friese et al. 2021). Additionally, the 2023 report from the European Sea Ports Organisation (ESPO) highlights that air quality and climate change have been high priorities for ports since 2017 (Puig et al. 2023). Also, notable variations exist in adopting emissions reduction measures across different ports. Furthermore, ports are gaining increasing attention from the energy industry due to their potential to evolve into hubs for alternative fuel sources, thereby supporting the transition to sustainable energy for all maritime industries (IAPH 2022). Moreover, involving ports in green shipping corridors guides the maritime industry toward more environmentally friendly conditions and facilitates a smooth transition toward alternative fuels (Svendsen et al. 2023).

Nonetheless, the maritime industry, including ports, continues to show notable weaknesses in using renewable energy sources. Achieving sustainability and implementing green practices in ports necessitates consideration of diverse factors influencing the shift towards environmentally friendly operations. The process of "greening" a port should account for variations in port governance structures. Port governance significantly influences the tools available for a port to influence environmentally conscious behaviour, with port authorities exerting more influence over green initiatives within their jurisdiction. The extent of government policies and the governance model of a country's ports directly impact the level of implementation of green policies (Munim, Sornn-Friese, and Dushenko 2020; ESPO 2021; Sugimura 2023; Alamoush, Ölçer, and Ballini 2022).

To address this gap, ports should establish energy-based criteria for assessing sustainability, incorporating metrics for measuring CO2 emissions. Implementing smart and clean energy systems in ports becomes urgent to mitigate CO2 emissions effectively (Hoang et al. 2022). Furthermore, the technical and operational measures are crucial in defining the ports' capacity to lower GHG emissions and integrate sustainability into maritime transport. However, their significance notwithstanding, these measures are insufficient to substantially reduce GHG emissions without implementing effective schemes (Alamoush, Ballini, and Ölçer 2020; Alamoush, Ölçer, and Ballini 2022). In this endeavour, achieving a balance among environmental considerations, energy costs, and the operational budget of ports is crucial.

However, the governance model within ports significantly impacts the feasibility of implementing such measures, potentially as a barrier to reducing GHG emissions within the port. The manner in which a port is governed not only shapes its technical management and port policy procedures but also influences its environmental strategies. By comparing each type, this study explores the correlation between port governance models and the potential for adopting sustainable practices to reduce GHG emissions from ports.

3. TYPES AND HISTORICAL DEVELOPMENT OF PORT GOVERNANCE

3.1 Evolution of Port Governance

Understanding the importance of port governance in developing green ports and reducing GHG emissions requires examining why governance matters. As a structural framework, corporate governance outlines the rights and responsibilities of various organisations, including the board, managers, shareholders, and other parties. It establishes the rules and procedures managing decision-making processes and defines corresponding responsibilities (Ángeles Fernández-Izquierdo et al. 2020).

At the port level, port governance is determined by the interplay between the general administration body and port authority at the port level. The port authority is responsible for formulating the port's structure and strategy, considering the inherent risks associated with its activities (Brooks and Pallis 2008). Furthermore, the principles of port governance encompass the interactions among businesses, public or private stakeholders, organizations, and the entities authorized to carry out activities on their behalf. This involves the dynamics between the public and private sectors (Notteboom, Pallis, and Rodrigue 2022).

The majority of ports were under the operation and management of public entities referred to as Port Authorities until 1980. In the late 1970s and early 1980s, the commencement of port privatisation necessitated the development of enhanced regulations and regulatory models (Ferrari, Haralambides, and Tei 2022; Brooks and Pallis 2012). These models are needed to accommodate the complicated interactions among multinational companies, adhering to public tender rules and obligations.

3.2 Port Governance Models

Over the years, the classification of port categories has changed, incorporating criteria such as the nature of services offered, the port's global orientation or geographical location, the ownership structure of its infrastructure and superstructure, and the status of dock labour and management. The World Bank (2022) categorises the port's governance (Administration Models) into four main classifications, illuminating the distinct characteristics and operational dynamics of various ports globally. The four principal port governance include the public service port, the tool port, the landlord port, and the fully privatised port, as shown in Figures 1,2,3 and 4. Moreover, the port economics management organisation introduced an additional category known as Corporatized ports. This model is less prevalent in practice, positioned between private and landlord ports (Notteboom, Pallis, and Rodrigue 2021).

These port governance models operated within ports influence the managerial ability, adaptability, and awareness of port administrators in facilitating the integration of new policies and technologies aimed at transitioning the port towards environmental sustainability in GHG emission reduction.

3.2.1 Public Service Port

The distinctions among these four port governance models are rooted in port functions and the growing privatisation trend in port management and operation. Illustrated in Figure 1, the Ministry of Transport typically oversees all activities of the public service port (World Bank 2022). The port authority of public service ports is responsible for a comprehensive array of port-related services and includes all associated infrastructure and superstructure. Cargo handling activities may be delegated to distinct public entities (World Bank 2022; Notteboom, Pallis, and Rodrigue 2021).

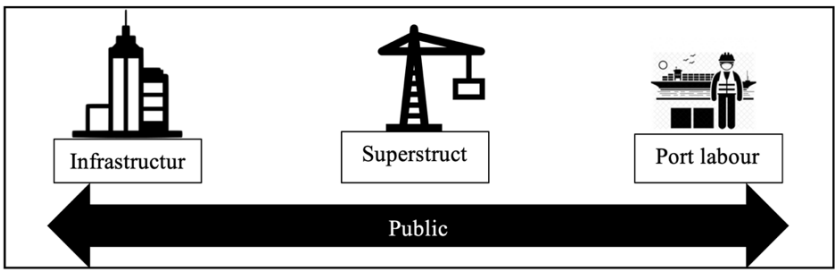

Figure 1: Public Port shows a collaborative model with shared responsibilities under government control. Source: (Author 2023)

3.2.2 Tool Port

In the tool port model, the port authority retains ownership of, develops, and oversees both the port superstructure and infrastructure, encompassing cargo handling equipment. This model is closely similar to the public service port; however, in the tool port, private entities handle cargo operations, as shown

in Figure 2. The port authority maintains ownership of specific cargo-handling equipment, for instance, cranes and forklifts (World Bank 2022). As Notteboom, Pallis, and Rodrigue (2021) highlighted, a tool port serves as a transitional phase between a service port and a landlord port in various instances.

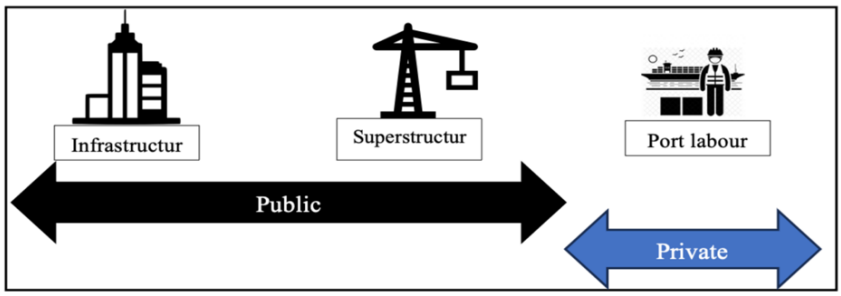

Figure 2: Tool Port integrates private sector tools into the port with public ownership.
Source: (Author 2023)

3.2.3 Landlord Port

The predominant port management model, aligning with the governance structure of many European ports, is the Landlord model. According to the ESPO (2021), this model prevails in larger and medium-sized ports. In the Landlord model, illustrated in Figure 3, private sector operations, particularly cargo handling activities, engage in leasing port infrastructure, especially terminals, and provide and maintain their superstructure and buildings. Concurrently, the port authority maintains control over the land where port development occurs through ownership or complete exploitation rights.

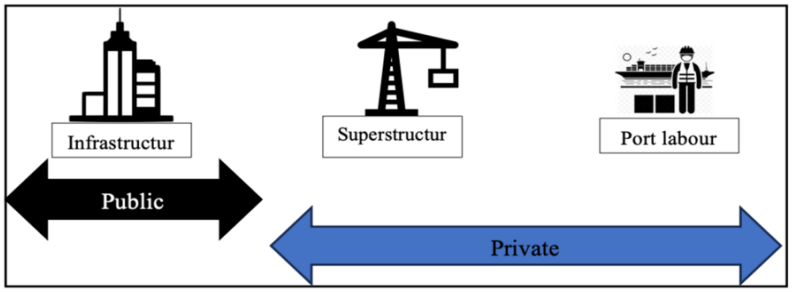

Figure 3: Landlord Port pushes the public sector to act as a landlord.
Source: (Author 2023)

3.2.4 Private Service Port

The private service ports model is the outcome of the complete privatisation of the port facility, signifying that almost all port functions are under private control. This model is relatively rare globally, differing significantly from the public service port model. In this type of port model, as shown in Figure 4, port land is privately owned, requiring the government to sell the port to the private sector, which then develops both the port infrastructure and superstructure (World Bank 2022). Nevertheless, public entities can still be shareholders, allowing them to influence strategies deemed to be in the public interest (Notteboom, Pallis, and Rodrigue 2021).

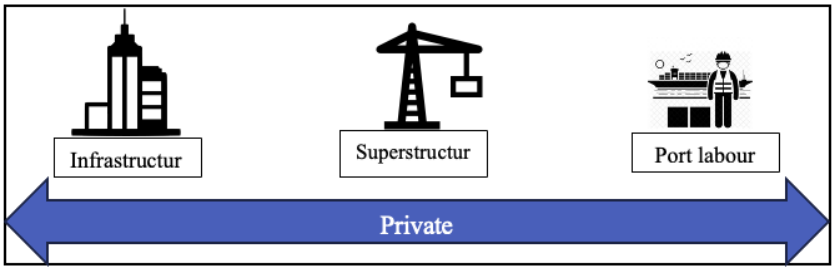

Figure 4: A Private Ship Port is a privatised model with private entities dominating ownership and operation. Source: (Author 2023)

4. RESEARCH METHODOLOGY

This study uses a comparative analysis method to examine the differences among various port governance models and their impact on implementing strategies to reduce GHG emissions and create environmentally friendly green ports. Comparative analysis helps describe and compare different cases, showing similarities and contrasts among cases (Pickvance 2001; Collier 1993). By using this approach, we gain insights into which type of port governance is an effective transition toward sustainable energy practices and the mitigation of GHG emissions. The findings offer valuable guidance for policymakers, port authorities, and stakeholders interested in transitioning toward more sustainable and environmentally friendly port practices and clean maritime industry.

This study focuses on key variables within port governance models, specifically the conversion of a port into a green port, which generally encompasses three main strategies: involving stakeholders, enacting green policies, and conducting scientific monitoring. The focus on these main variables aims to assess their relationship across different organisations, such as public or private sectors.

Additionally, to examine the implementation of green policies, an analysis is being conducted on 56 ports listed on the Environmental Ship Index (ESI) website, which have adopted the ESI framework. This analysis aims to assess the relationship between port governance models and adopting green policies to reduce GHG emissions. By examining whether the relationship observed in one organisation holds true in others, the study seeks to identify patterns and understand the influence of these core variables on port governance models.

5. ANALYSING THE ROLE OF PORT GOVERNANCE MODELS IN MITIGATING GHG EMISSIONS

Establishing and growing transportation infrastructures, particularly ports, carry the risk of significant environmental harm. The transition to a green port poses a considerable challenge, given the complicated system managing various transition factors within the port. In addition, a green port should seek to attain efficiency in economic and environmental measurements simultaneously (Chang 2013). Consequently, there is increasing support for adopting green principles in guiding the development and operations of port businesses. This shift aims to restrain environmental degradation, mitigate biodiversity loss, and discourage unsustainable utilisation of natural resources.

Implementing a strategy or system to reduce GHG emissions is not the only requirement. Ports also need to adopt technical and operational measures to minimise GHG emissions (Acciaro and Wilmsmeier 2015). Alamoush, Ballini, and Ölçer (2020) categorise these measures into several groups: Information Measures, Equipment Measures, Energy Measures, Energy Efficiency Measures, Operation Measures, and Ship-port Interface Measures. Adopting information measures is important to initiate those measures for reducing GHG emissions at ports. These measures are crucial in monitoring emissions and energy consumption, establishing a baseline and inventory, and providing a means to track emissions (Alamoush, Ölçer, and Ballini 2022b). The effectiveness of implementing these measures is notably influenced by port governance, mainly through the engagement of the private sector and the extent of stakeholder involvement in the port.

Public service ports face significant barriers, mainly in terms of funding and financial controls, which directly impact three key variables: stakeholder involvement, the implementation of green policies, and scientific monitoring. According to the World Bank (2022), public ports heavily depend on government funds, exhibiting limited problem-solving capabilities and a lack of innovation, especially in developed states. This underscores a deficiency in stakeholder involvement in the transition to green ports, as shown in Table 1. Moreover, this governance model requires updates to its regulatory frameworks and a shift in mindset resistant to change. Overcoming these challenges involves addressing funding restrictions, promoting stakeholder engagement, fostering visionary regulatory frameworks, and bridging gaps to facilitate a transition towards a greener and more environmentally friendly port.

During the transition, the tool port governance encounters more challenges than all the other models. This challenge is attributed to private operators who do not own major equipment, which creates a conflict of interest and leads them to function as labour pools without prioritising emission concerns, port strategy, and green plans (Munim, Sornn-Friese, and Dushenko 2020b). Additionally, as mentioned in the World Bank (2022) report, the tool and public service ports face the same risks of underinvestment and lack of innovation.

In the landlord port governance model, stakeholders wield significant influence over port management and operations, even reaching the port authority in power. A key challenge landlord ports face involves long-term contracts with high costs, resulting in extended investment payback periods (World Bank 2022). Despite being profit-oriented, the private sector's loyalty to the port increases due to these long contracts, fostering a greater likelihood of investments. Additionally, it is more adaptable to market demands than the public sector. This governance model facilitates increased private sector involvement as stakeholders, growing funds, promoting innovation, and expanding market share. As underlined in the ESPO (2021) report, when a port authority pursues sustainable and monitoring policies to reduce GHG emissions, the private sector can offer support through incentives provided by the port authority and government.

In the fully privatised port governance model, as with any private business, the primary objective is maximising profits, which can lead irrespective of GHG emissions. With limited regulatory oversight and minimum government involvement, there may be inconsistencies in adopting environmentally friendly practices. In addition, ports can control monopolistic behaviour (World Bank 2022). However, private entities can contribute to efficiency and innovation in labour practices for sustainability. Moreover, these entities possess flexibility in investments without direct intervention from the port authority or government. This indicates that this governance model has a limited potential for

involvement in green policies and monitoring the emissions released by the port (Sornn-Friese et al. 2021).

Table 1. Comparative of Port Governance Models in the likelihood of applying the three variables for the top 50 container ports. Source: (Author 2023)

Key variables	*Involving stakeholders*	*Enacting green policies*	*Conducting scientific monitoring*
Public service port	Low	Medium/High	Medium/High
Tool port	Low	Low	Low
Landlord port	Hight	Medium/High	Medium/High
Fully privatised	Low	Low/Medium	Low/Medium

An analysis conducted by this study, utilising the Container Port Performance Index 2022 data, which was released by the World Bank (2022b), for the top 50 container ports, aimed to assess the applicability of the three variables across all port governance models. Table 1 provides an overview of the adoption levels. Furthermore, scientific monitoring, a primary focus and one of this study's main variables, encounters a special challenge due to insufficient port reporting. Over half of the top 50 container ports globally in maritime shipping did not show maturity in reporting their GHG emission data, underscoring a transparency issue encountered by the green ports approach (Cammin, Brüssau, and Voß 2022).

In addition, Operating ships within the port are identified as a major GHG emission source. The IAPH (2023) has introduced the ESI) to assess the environmental impact of ships. This ESI initiative primarily targets ship emissions and offers valuable insights into implementing green policies to reduce ship emissions across diverse governance models. In many cases, financial incentives are applied based on the criteria for assessment, including emissions of Sox, NOx, CO2, and the utilization of Onshore Power Supply (OPS) by visiting ships.

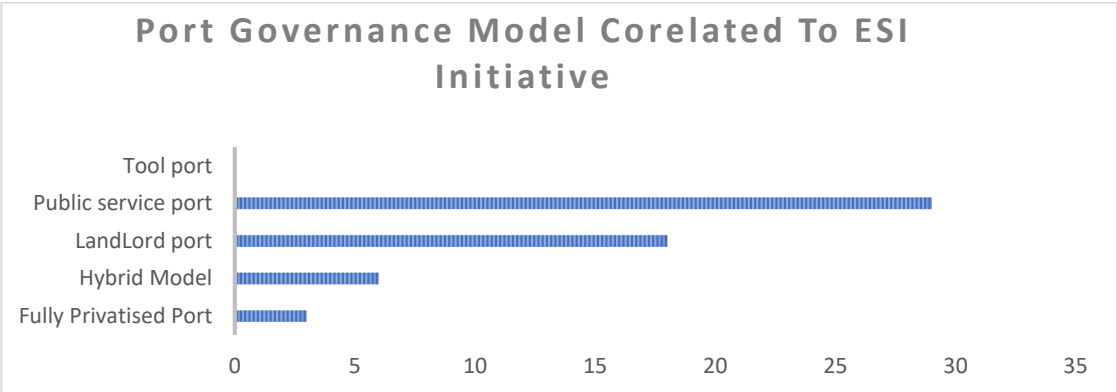

Figure 5: Port governance models correlated to ESI initiative.

Source: (Author 2023)

To explore the implementation of green policies within port governance models, an analysis of all ports that have adopted the ESI (56 ports), assembled from the Environmental Ship Index (2023) and the ports' websites, indicates that approximately 52% of ports follow the public service governance model, followed by 32% adopting the landlord port governance model. In contrast, the fully privatised port model demonstrates the least commitment, with only 5%, as illustrated in Figure 5. Notably, according to the statistics, the Tool Port governance model shows no interest in this approach, accounting for 0%. The remaining 11% is in the hybrid (mixed) governance model.

6. DISCUSSION

In the transition to a green port, there is not a one-size-fits-all model. Each port governance model comes with its own set of cons and pros in implementing green policies. Furthermore, specific characteristics, locations, and externalities unique to each port contribute to the need for different governance models. Considerations include the port's closeness to a city and the expected impact, as well as the overall development status of the country, whether it is developed, developing, or a Small Island Developing State (SIDS).

Additionally, a significant concern is the high cost associated with transitioning to a green policy, which eventually passed on to end customers and local communities. This financial commitment drives policymakers to consider reverting to business as usual.

The alignment between port governance models and the goal of sustainability for reducing GHG emissions is a complex and slight interplay. Studies by Munim, Sornn-Friese, and Dushenko (2020b); Van Der Lugt, De Langen, and Hagdorn (2015) declare a positive correlation between government ownership and the presence of politically influenced board members with a port's commitment to sustainability practices and green policies. However, this correlation may not be universally applicable, as highlighted in this study. The landlord model, characterised by private sector involvement, is identified as having the potential to enforce green activities, including sustainability, in the long term.

Contrary findings by De Langen and Van Der Lugt (2017) suggest that more governance owners correlate with an increased focus on sustainability. Notably, government-owned ports are more likely to actively participate in green port initiatives and demonstrate a commitment to reducing GHG emissions. It is crucial to consider the context in which these studies are conducted, primarily in developed countries, and the diverse externalities faced by ports, such as their geographic location and the economic status of the surrounding communities.

Finally, this observation from the study underscores the potential for balancing port efficiency and sustainable practices within the landlord and public port governance models. In addition, it underscores the intention and vision of the government, port authority, and private sector to embrace a green policy, marking a crucial and primary step toward achieving a sustainable and environmentally friendly port. The nuances of port governance and its impact on sustainability underscore the need for a comprehensive and context-specific approach to address the complexities of transitioning ports to greener practices.

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