Maritime Education and Training and Operational Efficiency in Cameroon's Maritime Transport Industry: An Empirical Analysis of the Moderating Effect of Workforce Development

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Research Article

Abstract

This study examines how workforce development moderates the effect of maritime education and training on operational efficiency in Cameroon's maritime transport industry. The study adopted a survey and causal research design, collecting primary data from a sample of 344 respondents drawn from maritime transport operators, port authority staff, maritime training instructors and trainees, and regulatory personnel across Cameroon's maritime sector, using a structured Likert-type questionnaire. The study employed purposive sampling to ensure adequate representation across institutions, educational backgrounds, and experience categories. Because the dependent variables, maritime workforce development and operational efficiency, were constructed as bounded indices, the data were analyzed using Tobit regression estimated by maximum likelihood, alongside descriptive and correlation analyses. The findings revealed that maritime workforce development in Cameroon remains relatively low. Safety and environmental training and curriculum design emerged as the factors most strongly associated with workforce development outcomes. Meanwhile, technological integration remains notably underdeveloped across maritime training institutions. Regarding operational efficiency, the results showed that skills development and career progression, when considered independently of workforce development, have significant negative effects on operational efficiency, whereas gender inclusion and workforce diversity have significant positive effects. Critically, the interaction analysis shows that workforce development significantly moderates these relationships: it substantially strengthens the positive effect of skills development and career progression on operational efficiency, weakens the effects of recruitment and gender inclusion, and does not significantly moderate the effect of workforce diversity. The study recommends that maritime training institutions and regulatory authorities in Cameroon prioritize the strengthening of curriculum design, safety and environmental training, and technological integration as foundations for workforce development, and that human resource interventions such as recruitment, career progression, and inclusion policies be deliberately aligned with workforce development systems to maximize their contribution to operational efficiency.

Keywords: Maritime education and training, workforce development, operational efficiency, Tobit regression, moderating analysis.

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1. Introduction

The maritime transport industry plays a central role in global trade and economic development, with an estimated eighty percent of world merchandise trade by volume carried by sea (UNCTAD, 2022). This dominance of maritime transport in global logistics has placed considerable emphasis on the quality, competence, and adaptability of the maritime workforce, as the efficiency of ports, shipping operations, and related services depends substantially on the skills and capabilities of the personnel who operate within them (International Maritime Organization [IMO], 2021). Globally, the maritime sector has undergone rapid transformation driven by technological innovation, automation, and increasingly stringent safety and environmental regulations, which have heightened demand for a workforce that is not only technically proficient but also continuously updated through structured training and education (Manuel, 2017).

Within this global context, maritime education and training have emerged as critical levers for ensuring that workforce competencies keep pace with industry developments. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), administered by the IMO, established minimum international standards for seafarer training and certification, recognizing that inadequately trained personnel pose risks not only to operational efficiency but also to safety and environmental sustainability (IMO, 2021). Scholars have consistently argued that the effectiveness of maritime training systems depends on curriculum design, the extent of technological integration in training delivery, and the robustness of regulatory and institutional oversight (Manuel, 2017; Progoulaki & Theotokas, 2016). Where these factors are weak or poorly coordinated, maritime workforce development tends to lag behind industry needs, with consequences for the operational performance of ports and shipping enterprises (Lee & Lin, 2020).

In the African context, maritime transport has assumed growing significance as countries seek to leverage their coastal and port infrastructure to support regional and international trade, particularly under frameworks such as the African Continental Free Trade Area (AfCFTA), which is expected to substantially increase intra-African maritime trade volumes (United Nations Economic Commission for Africa [UNECA], 2021). However, numerous studies highlight persistent workforce development challenges across African maritime administrations, including inadequate training infrastructure, limited technology adoption in maritime training institutions, weak regulatory enforcement, and a shortage of qualified maritime educators and trainers (Asariotis & Premti, 2019; Ndikom, 2013). These challenges are linked to broader concerns about the operational efficiency of African ports, which continue to lag behind counterparts in other regions in cargo handling times, vessel turnaround, and overall productivity (World Bank, 2022).

Cameroon's maritime transport sector reflects many of these regional dynamics. The country's maritime trade is anchored by the Port Autonome de Douala, historically the principal gateway for the country's import and export trade, alongside the more recently developed deep-sea port of Kribi, which was conceived to decongest Douala and to position Cameroon as a logistics hub for Central Africa, and the port of Limbe (Port Autonome de Douala, 2020; Tchouankoua & Mbiazi, 2019). The expansion of these port facilities has been accompanied by growing recognition that infrastructural investment alone is insufficient to guarantee operational efficiency, and that a correspondingly skilled and well-developed maritime workforce is required to operate, maintain, and manage these facilities effectively (Ngoa Tabi & Atangana, 2021). Despite this recognition, maritime training institutions in Cameroon have faced documented constraints, including limited integration of modern technology into training curricula, uneven implementation of safety and environmental training programs, and regulatory frameworks whose enforcement does not always match their formal scope (Ministry of Transport, Cameroon, 2020; Tchouankoua & Mbiazi, 2019).

These constraints raise important questions about the extent to which existing regulatory and institutional frameworks, curriculum design practices, technological integration efforts, and safety and environmental training programs translate into meaningful improvements in maritime workforce development in

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Cameroon. Furthermore, given that workforce development is widely theorized to mediate or moderate the relationship between skills development and broader organizational or sectoral performance outcomes (Becker, 1993; Wright & McMahan, 1992), it becomes equally important to understand whether, and to what extent, the level of workforce development achieved within Cameroon's maritime transport industry shapes the relationship between skills development, institutional capacity, and operational efficiency. It is within this context, marked by the strategic importance of the maritime sector to Cameroon's economy, the persistent workforce development challenges documented within the sector, and the limited empirical attention this relationship has received in the Cameroonian context, that the present study is situated.

Cameroon's maritime transport industry occupies a strategic position in the country's trade, logistics, and broader economic development, anchored by key port complexes such as the Port Autonome de Douala, the deep-sea port of Kribi, and the port of Limbe. The efficient and safe conduct of maritime operations within this industry depends heavily on the availability of a well-trained, competent, and adequately developed workforce. However, despite the centrality of the sector to national economic activity, maritime workforce development in Cameroon remains low, with descriptive evidence indicating that the average level of workforce development among sampled respondents stands at a relatively low to moderate level, well below what would be expected of a maritime workforce capable of meeting modern operational, safety, and technological demands.

This low level of workforce development is particularly concerning when considered alongside the state of the factors expected to drive it. Technological integration within maritime education and training institutions remains very low, suggesting that trainees and personnel are not being adequately exposed to the technological tools and systems increasingly required in modern maritime operations. Safety and environmental training, while moderately present, is unevenly implemented across institutions, raising concerns about how consistently maritime personnel are prepared to meet safety and environmental standards. Curriculum design, although moderately structured, and regulatory and institutional frameworks, although relatively present, have not translated into correspondingly strong workforce development, suggesting gaps between the existence of these structures and their effective implementation or impact.

Beyond workforce development itself, a further and arguably more consequential problem lies in the implications of low workforce development for the operational efficiency of Cameroon's maritime transport industry. Operational efficiency, as the ultimate measure of how well the sector converts its institutional, educational, and human resource investments into functional outcomes, is theoretically expected to depend on the extent to which the workforce is adequately developed. Where workforce development is low or inconsistent, it is plausible that even well-intentioned investments in skills development, governance structures, and institutional capacity may fail to produce the expected gains in operational efficiency, or may even produce adverse effects, as suggested by preliminary evidence that skills development alone is associated with a significant reduction in operational efficiency when the moderating influence of workforce development is not taken into account.

This raises a critical and underexplored problem: it is not yet sufficiently understood, within the context of Cameroon's maritime transport industry, how regulatory and institutional frameworks, curriculum design, technological integration, and safety and environmental training jointly shape the level of maritime workforce development, nor is it sufficiently understood whether, and to what extent, the level of workforce development achieved moderates the relationship between skills development and related institutional factors, on the one hand, and operational efficiency, on the other. Without a clear empirical understanding of these relationships, policymakers, training institutions, and maritime transport operators in Cameroon risk continuing to invest in skills development, regulatory reform, and institutional capacity-building without a clear sense of whether, or under what workforce development conditions, such investments translate into meaningful improvements in operational efficiency.

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It is against this background that the present study seeks to investigate the determinants of maritime workforce development in Cameroon's maritime transport industry, and to examine the moderating role of maritime workforce development in the relationship between skills development and related institutional factors and operational efficiency, with a view to generating evidence that can inform more effective workforce development and institutional strategies within the sector.

2. Literature Review

A study by Dewan, Mustafi, Matos, and Godina (2024) investigated the effect of maritime education and training (MET) on seafarers' competence in energy-efficient ship operations, focusing on improving implementation of the Ship Energy Efficiency Management Plan (SEEMP). The study surveyed 144 seafarers across 42 shipping companies globally using structured questionnaires and applied structural equation modeling (SEM) to analyze how different training modalities simulator-based, company in-house, traditional onboard training, and IMO e-learning affected seafarers' knowledge, understanding, and practical proficiency. The results showed a statistically significant positive effect: seafarers who received simulator-based or computer-based training demonstrated higher knowledge, better understanding, and greater practical proficiency in energy-efficient operations than those who received only traditional onboard training. The authors concluded that MET, particularly when incorporating modern simulation and digital training, plays a critical role in developing specialized competencies required for contemporary maritime challenges such as energy efficiency and compliance with environmental regulations. Limitations included a modest sample size and a cross-sectional design, and the authors recommended longitudinal studies to assess the sustainability of training effects across multiple voyages.

Hidayati, Abdulhak, Wahyudin, and Rusman (2020) conducted a case study examining how maritime learning activities influence students' competency development. The research aimed to test whether institutional commitment, including government support, curriculum quality, training resources, and engagement between schools and industry, affects competency development among junior-high maritime-track students in Indonesia. The study sampled 175 students and collected data through questionnaires, interviews, and focus-group discussions with students, teachers, and school principals. Using SEM, the authors found that government commitment, well-structured curriculum, and structured maritime learning activities positively influenced competency development. Specifically, these factors enhanced students' technical and foundational maritime skills, laying the groundwork for future workforce readiness. Limitations included reliance on self-reported competencies and a lack of longitudinal follow-up, which prevented assessment of how competencies translated into professional performance.

Research on simulator-based and technologically enriched MET emphasizes the importance of practical, immersive learning experiences. Pan, Oksavik, and Hildre (2024) indicated the role of co-designed simulators in anticipating future skill requirements and enhancing MET effectiveness. Their qualitative research, including workshops, interviews, and expert discussions, demonstrated that simulator-based learning develops both tacit and technical skills and improves decision-making, emergency response, and environmental compliance. The study concluded that simulator-based training should be systematically integrated into MET curricula to enhance workforce resilience and adaptability. However, the authors noted that access to simulation technology is uneven, particularly in developing countries, and longitudinal empirical evidence on training outcomes remains limited.

Mojafi (2023) explored how evolving maritime industry demands, automation, digitalization, regulatory changes, and environmental pressures challenge the adequacy of existing MET curricula. Using a mixed-methods approach that combined global fleet data, seafarer demand trends, curriculum reviews, and interviews with industry stakeholders, the study found that many MET programs lag in integrating competencies such as digital literacy, environmental compliance, soft skills, and lifelong learning. As a result, graduates may be ill-prepared for modern maritime operations despite formal certification. The study concluded that MET curricula require substantial reforms, including adopting simulation and digital

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training, integrating soft skills, and aligning with current industry demands, to ensure workforce preparedness and operational efficiency.

Finally, Wulandari and Simanjuntak (2024) investigated MET's impact on human resource management in maritime firms by interviewing 70 STIP Jakarta graduates. The study examined how MET prepared graduates for real-world maritime work, including digital adoption, innovation, professionalism, and compliance with IMO STCW standards. The thematic analysis found that MET strengthened technical competence, professional attitudes, regulatory awareness, and readiness to adopt technological tools, which in turn supported firm-level operational efficiency and a culture of compliance. Limitations included potential sample bias, as only employed graduates were interviewed, and the lack of objective performance measures, which restricts the generalizability of the findings.

In the context of early maritime education, Hidayati, Abdulhak, Wahyudin, and Rusman (2020) conducted a quantitative case study to examine how government commitment, curriculum quality, and industry engagement influence the development of student competencies in maritime learning activities in Indonesian junior high schools. Using structural equation modeling (SEM) on data collected from 175 Grade IX students through questionnaires, interviews, and focus group discussions across multiple schools, the study found that institutional commitment and structured maritime learning activities positively affected student engagement and competency development, particularly in areas such as career decision-making, entrepreneurial aspirations, and appreciation of marine life. The authors concluded that initiating maritime education and training (MET) at the secondary school level, when supported by government policy and curriculum development, can build foundational competencies that contribute to an expanded future maritime workforce pipeline. However, they also noted key limitations, including reliance on self-reported competency measures and the absence of longitudinal follow-up to assess whether such early learning translates into actual maritime career outcomes. Empirical research on modern MET and seafarer competence illustrates the impact of structured, technology-enhanced training on specialized operational competencies.

Kim et al. (2021) argue that simulator-based maritime training provides an integrated educational continuum that bridges theoretical knowledge and practical skills in a controlled, risk-free environment, aligning training practice with STCW competency standards and operational requirements. Their work emphasizes that systematic instructional design and formative assessment within simulator settings enhance learner engagement and the applicability of skills to real-world maritime tasks, indicating the pedagogical value of simulation in competency development. Relatedly, broader analyses of simulator-based training literature underscore that simulation has become a central focus of maritime training research, evolving from basic navigation exercises to complex scenario-based assessments that integrate technical and non-technical skills. For instance, a recent review in the WMU Journal of Maritime Affairs mapped conceptual developments in simulation-based MET, noting that human factors, resource management, and authentic assessment are key themes in the field's evolution. This research suggests that simulation's role in maritime education is expanding, though empirical work linking simulation outcomes to workforce and operational performance remains emerging. MET instructors' pedagogical competence is also increasingly recognized as a determinant of training quality.

A recent theoretical-empirical analysis by Caesar (2023) proposed a "Skill Resilience Framework" for maritime workforce sustainability amid technological, regulatory, and environmental change. Using a web-based survey of 305 ship officers worldwide, combined with industry report analysis and academic literature review, the author identified growing skill gaps and argued that existing MET must evolve to include not only technical competencies but also adaptability, continuous learning, digital skills, and resilience. The study indicates that a shortage of a highly skilled, adaptable maritime workforce threatens the sustainability of maritime operations under changing global conditions, and recommends a paradigm

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shift in training, recruitment, and retention strategies to build a resilient workforce. This contributes empirically to understanding workforce dynamics, though the author notes limitations: survey data reflects perceptions rather than objective performance, and the proposed framework requires further longitudinal validation in diverse geographic contexts.

The reviewed literature generally establishes that Maritime Education and Training (MET) enhances seafarers' competence, technical skills, digital readiness, adaptability, and professional preparedness (Dewan et al., 2024; Hidayati et al., 2020; Pan et al., 2024). Simulator-based and technology-enhanced training have particularly been found to improve practical skills, decision-making, safety, environmental compliance, and readiness for modern maritime operations (Kim et al., 2021; Pan et al., 2024). Mojafi (2023) further notes that changing technological, regulatory, and environmental demands require continuous reforms in MET curricula, while Wulandari and Simanjuntak (2024) link MET to professionalism, innovation, and operational readiness. Caesar (2023) emphasizes workforce adaptability, continuous learning, digital skills, and resilience as essential for sustainable maritime operations. However, existing studies have focused mainly on individual competencies and workforce preparedness, with limited empirical attention to operational efficiency at the organizational or industry level. Furthermore, workforce development has rarely been examined as a moderating factor in the MET–operational efficiency relationship. Most evidence also comes from Asian and international contexts, leaving limited empirical evidence from Cameroon and other African maritime industries. The present study therefore addresses these contextual, conceptual, and empirical gaps by examining the effect of MET on operational efficiency in Cameroon's maritime transport industry and assessing the moderating role of workforce development.

3. Methodology

Cameroon's maritime transport industry is anchored around its principal port complexes, including the Port Autonome de Douala, the deep-sea port of Kribi, and the port of Limbe, which together form the backbone of the country's maritime trade, logistics, and transport operations. These ports are supported by a network of maritime training institutions, regulatory bodies, and transport operators that ensure safe, efficient, and skilled maritime operations. The maritime sector in Cameroon operates under the regulatory oversight of national maritime authorities and is shaped by international conventions on maritime training, safety, and environmental protection, as well as domestic policy and institutional frameworks.

The study population comprises individuals working in Cameroon's maritime transport and maritime training institutions, including maritime transport operators, port authority staff, maritime training instructors and trainees, regulatory personnel, and other professionals directly engaged in the maritime sector. The population was defined to include respondents with varying levels of educational attainment, ranging from primary to tertiary education, and varying lengths of professional experience, ranging from less than five years to more than ten years, in order to capture a broad and representative range of perspectives on workforce development and operational efficiency within the sector.

A total sample of 344 respondents was drawn from the population of maritime transport and training personnel in Cameroon. This sample size was determined using established sample size determination procedures appropriate for survey-based research involving a large, dispersed population, using the Yamane (1967) formula, and was considered sufficient to support reliable statistical estimation, including descriptive analysis, correlation analysis, and regression-based modeling.

A purposive sampling technique was employed to ensure adequate representation of respondents across the different maritime institutions, educational backgrounds, and experience categories that constitute the population

The research instrument used in this study is a structured questionnaire comprising closed-ended items developed on a Likert-type scale, supplemented by items capturing respondents' demographic and professional background, including educational attainment and years of professional experience (please see the appendix). The questionnaire was designed to capture the core constructs of the study, namely

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maritime workforce development, regulatory and institutional framework, curriculum design, technological integration, and safety and environmental training, alongside indicators relevant to operational efficiency and skills development. The researchers developed the instrument after reviewing relevant literature on maritime education, training, and transport industry performance, and refined it through consultation with the research supervisor and subject-matter reviewers familiar with the maritime transport sector. The researchers used face, content, and construct validity to ensure the research instrument's validity. The study indices were constructed using Multiple Correspondence Analysis (MCA) and then normalized to obtain comparable index values for each variable.

The first model examines the influence of regulatory and institutional framework, curriculum design, technological integration, and safety and environmental training, together with relevant educational and experience controls, on maritime workforce development. The model is specified as follows:

$$WFD_i = \beta_0 + \beta_1 RIF_i + \beta_2 CUD_i + \beta_3 TIM_i + \beta_4 SET_i + \beta_5 PEDU_i + \beta_6 SEDU_i + \beta_7 TEDU_i + \beta_8 Less5years_i + \beta_9 b5to10yrs_i + \varepsilon_i$$

Where:

WFD = Maritime workforce development index (dependent variable)

RIF = Regulatory and institutional framework index

CUD = Curriculum design index

TIM = Technological integration index

SET = Safety and environmental training index

PEDU = Primary education (dummy)

SEDU = Secondary education (dummy)

TEDU = Tertiary education (dummy)

Less5years = Less than five years of experience (dummy)

b5to10yrs = Between five and ten years of experience (dummy)

β_0 = constant term

$\beta_1 \ldots \beta_9$ = coefficients to be estimated

ε = error term

Model Two: Moderating Effect of Workforce Development on Operational Efficiency

The second model assesses the moderating role of maritime workforce development in the relationship between skills development and related institutional variables, on the one hand, and operational efficiency, on the other. The model is specified as follows:

$$OE_i = \beta_0 + \beta_1 SDE_i + \beta_2 RECT_i + \beta_3 CAP_i + \beta_4 GIN_i + \beta_5 WDI_i + \beta_6 (SDE \times WFD)_i + \beta_7 (RECT \times WFD)_i + \beta_8 (CAP \times WFD)_i + \beta_9 (GIN \times WFD)_i + \beta_{10} (WDI \times WFD)_i + \varepsilon_i$$

Where:

OE = Operational efficiency index (dependent variable)

SDE = Skills development index

RECT = Recruitment-related index

CAP = Capacity-related index

GIN = Governance/institutional index

WDI = Work design/infrastructure index

WFD = Maritime workforce development index (moderating variable)

SDE×WFD, RECT×WFD, CAP×WFD, GIN×WFD, WDI×WFD = interaction terms capturing the moderating effect of workforce development on each respective relationship

β_0 = constant term

$\beta_1 \ldots \beta_{10}$ = coefficients to be estimated

ε = error term

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In both models, β0 represents the baseline or autonomous level of the dependent variable in the absence of the explanatory variables, while the remaining coefficients measure the marginal effect of each explanatory variable, or interaction term, on the dependent variable, holding all other variables constant. The interaction terms in Model Two are of particular interest, as their coefficients indicate whether, and to what extent, workforce development strengthens or weakens the relationship between each explanatory variable and operational efficiency.

The data collected were coded, cleaned, and analyzed using statistical software appropriate for survey-based econometric analysis. Descriptive statistics, including means, standard deviations, and minimum and maximum values, summarized the distribution of the study variables, while pairwise correlation analysis examined the direction and strength of association among variables before regression estimation.

Because the dependent variables in both models, maritime workforce development and operational efficiency, are constructed as bounded indices restricted to the interval between zero and one, the study employed Tobit regression for estimation. The Tobit model is appropriate because it explicitly accounts for the censored nature of the dependent variable at its lower and upper bounds, avoiding the bias that would otherwise arise from applying standard linear regression to a variable that cannot take values outside a defined range. The Tobit model is estimated by maximum likelihood, and its output includes a sigma parameter representing the estimated standard deviation of the error term, along with a pseudo R-squared statistic and a likelihood ratio chi-squared statistic, which replace the conventional R-squared and F-statistic associated with ordinary least squares estimation.

4. Result and Discussion

Table 1 presents descriptive statistics for the key variables used in the study. The mean value of maritime workforce development is 0.303, with a standard deviation of 0.197, indicating a relatively low to moderate level of workforce development across the sampled respondents, with some variation among observations. This suggests that workforce development outcomes are not uniformly distributed across Cameroon's maritime transport industry.

Table 1: Descriptive Statistics of Variables used in the Model

Variable	Obs	Mean	Std. Dev.	Min	Max
WFD	344	.303	.197	0	1
RIF	344	.628	.222	0	1
CUD	344	.533	.202	0	1
TIM	344	.081	.172	0	1
SET	344	.37	.255	0	1
PEDU	344	.105	.307	0	1
SEDU	344	.148	.356	0	1
TEDU	344	.718	.451	0	1
Less5years	344	.407	.492	0	1
b5to10yrs	344	.395	.49	0	1
abov10yrs	344	.198	.399	0	1

The mean value of the regulatory and institutional framework is 0.628 with a standard deviation of 0.222, indicating a relatively high average level of regulatory and institutional presence within the sector. However, the standard deviation suggests moderate variability, meaning that the strength and effectiveness of regulatory structures differ across institutions or respondents.

Curriculum design has a mean value of 0.533 with a standard deviation of 0.202, indicating a moderately strong presence of structured curriculum practices in maritime education and training institutions. The relatively low standard deviation suggests that responses are fairly consistent, implying a general agreement on the state of curriculum design.

Technological integration in maritime education and training has a very low mean value of 0.081 with a

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standard deviation of 0.172. This indicates that technological integration is still at a low level within the maritime training system in Cameroon. The relatively high standard deviation compared to the mean suggests uneven technology adoption across institutions, with some having limited or no integration.
Safety and environmental training has a mean value of 0.37 with a standard deviation of 0.255, indicating a moderate level of implementation across the sector. The variation suggests that while some institutions emphasize safety and environmental training, others may not fully integrate it into their programs.
Primary education has a mean value of 0.105 with a standard deviation of 0.307, indicating that a relatively small proportion of respondents have only primary education. The high standard deviation compared to the mean suggests considerable variation, meaning that educational attainment is not evenly distributed across the sample.
Secondary education has a mean value of 0.148 with a standard deviation of 0.356, indicating that a modest proportion of respondents have secondary education as their highest qualification. The relatively high standard deviation suggests diversity in educational backgrounds among respondents.
Tertiary education has a mean of 0.718 and a standard deviation of 0.451, indicating that most respondents have tertiary education. However, the high standard deviation reflects variation in the distribution, suggesting that while tertiary education is dominant, other educational levels are still notably present.
Less than five years of experience has a mean of 0.407 and a standard deviation of 0.492, indicating that a significant proportion of respondents are relatively new entrants to the maritime sector. The high standard deviation suggests a near-balanced distribution between those with and without this level of experience.

Table 2: Pairwise Correlations Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) WFD	1.000										
(2) RIF	0.510	1.000									
(3) CUD	0.609	0.693	1.000								
(4) TIM	0.356	0.202	0.357	1.000							
(5) SET	0.761	0.479	0.436	0.289	1.000						
(6) PEDU	-0.131	-0.186	-0.084	-0.093	0.053	1.000					
(7) SEDU	0.018	-0.019	0.080	-0.116	-0.161	-0.143	1.000				
(8) TEDU	0.047	0.077	-0.030	0.151	0.092	-0.546	-0.666	1.000			
(9) Less5years	0.220	-0.074	0.111	0.037	0.005	-0.187	0.237	-0.138	1.000		
(10) b5to10yrs	-0.110	0.038	0.002	0.015	0.081	0.326	-0.254	0.031	-0.658	1.000	
(11) above 10 yrs	-0.115	0.041	-0.073	-0.068	-0.102	-0.170	0.019	0.133	-0.411	-0.342	1.000

Between five and ten years of experience has a mean value of 0.395 with a standard deviation of 0.490, indicating that a similar proportion of respondents fall within this mid-level experience category. The high standard deviation again suggests a fairly even distribution within the sample.
Above ten years of experience has a mean of 0.198 and a standard deviation of 0.399, indicating that fewer respondents are highly experienced. The standard deviation suggests some variation, but overall, long-serving professionals are less represented in the sample compared to other experience categories.
The pairwise correlation matrix above indicates the degree and direction of association among the study variables. The correlation between maritime workforce development and the regulatory and institutional framework is positive (0.510), suggesting a moderate direct relationship between the two variables. This implies that improvements in regulatory and institutional structures are associated with higher levels of maritime workforce development.
The correlation between maritime workforce development and curriculum design is also positive (0.609), indicating a relatively strong direct relationship. This suggests that better curriculum design in maritime education and training is closely associated with improved workforce development outcomes. Similarly,

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the correlation between maritime workforce development and technological integration is positive (0.356), showing a weak to moderate relationship and implying that technological integration is associated with improvements in workforce development, though not strongly.
The correlation between maritime workforce development and safety and environmental training is strongly positive (0.761), indicating a very strong relationship. This suggests that safety and environmental training is a key factor associated with improvements in maritime workforce development.
Regarding educational variables, primary education shows a weak negative correlation with maritime workforce development (-0.131), suggesting that lower education levels are slightly associated with lower workforce development outcomes. Secondary education shows an almost negligible positive correlation (0.018), indicating no meaningful relationship with workforce development. Tertiary education also shows a very weak positive correlation (0.047), suggesting a minimal association with workforce development in the bivariate context.
For experience variables, less than five years of experience has a positive but weak correlation with maritime workforce development (0.220), suggesting that newer entrants are mildly associated with improved workforce development outcomes. Five to ten years of experience shows a weak negative correlation (-0.110), indicating a slight inverse relationship. Above ten years of experience also shows a weak negative correlation (-0.115), suggesting that higher experience levels are slightly associated with lower workforce development in the simple correlation analysis.
Among the explanatory variables, regulatory and institutional framework and curriculum design show a strong positive correlation (0.693), indicating that institutions with stronger regulatory systems tend to also have better-designed curricula. Curriculum design and safety and environmental training also show a moderate positive correlation (0.436), suggesting that improvements in curriculum are associated with stronger safety training systems.
Technological integration shows relatively weak correlations with most variables, including regulatory and institutional framework (0.202), curriculum design (0.357), and safety and environmental training (0.289), suggesting that technology adoption is not yet strongly integrated across maritime education systems.
Notably, curriculum design is strongly correlated with the regulatory and institutional framework (0.693), and maritime workforce development with safety and environmental training (0.761). These strong relationships suggest potential complementarity among institutional quality, training design, and workforce outcomes.
Table 3 indicates that, without interaction effects, skills development has a strong, negative, and statistically significant effect on operational efficiency. This suggests that improvements in skills development alone may reduce operational efficiency in Cameroon's maritime transport industry when not supported by broader workforce development systems. This finding is consistent with Moussir and Liouaeddine (2022), who found that training interventions do not always translate into productivity gains when structural and institutional constraints are present. It also aligns with de Oliveira *et al.* (2022), who argue that training systems, particularly simulator-based approaches, do not automatically improve operational outcomes unless effectively integrated into broader institutional and operational frameworks. Similarly, Kim *et al.* (2024) emphasize that inconsistent training implementation and limited institutional capacity can weaken the effectiveness of maritime education initiatives. The negative coefficient therefore suggests that isolated skills development may be insufficient and potentially inefficient without systemic workforce support mechanisms.
Recruitment shows a positive but statistically insignificant effect on operational efficiency, indicating that recruitment alone does not meaningfully influence efficiency outcomes. This finding aligns with Ogbulu et al. (2024), who stress that workforce expansion must align with strategic human capital development to produce productivity gains. It also supports Aniceto (2025), who argues that workforce inputs such as staffing must be complemented by structured training and operational integration to improve efficiency. Similarly, Arena *et al.* (2022) show that productivity gains depend not merely on workforce size but on how

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effectively organizations develop and use human capital. The insignificance of recruitment in this model therefore suggests that hiring practices in isolation are insufficient to enhance operational efficiency without accompanying workforce development structures.

Table 3: Moderation Results

VARIABLES	Model (Operational Efficiency)
SDE	-4.539***
	(0.747)
RECT	0.237
	(0.220)
CAP	-1.041***
	(0.243)
GIN	4.154***
	(0.624)
WDI	1.187**
	(0.603)
SDE*WFD	14.69***
	(2.101)
RECT*WFD	-3.728***
	(0.859)
CAP*WFD	2.060**
	(0.860)
GIN*WFD	-11.70***
	(1.652)
WDI*WFD	-1.167
	(1.114)
Constant	0.364***
	(0.113)
sigma	0.385***
	(0.0241)
Observations	344
Pseudo R2	0.2577
LR chi2(10)	118.83
Prob > chi2	0.0000

Career progression has a negative and statistically significant effect on operational efficiency, indicating that, when considered independently, promotion and advancement structures may reduce efficiency in the maritime transport industry. This finding contrasts with Aldoghan and Sundram (2023), who show that career development improves operational efficiency when combined with employee engagement and structured task-based training. It also aligns with Ogbulu *et al.* (2024), who emphasize that human resource development initiatives must align with organizational systems to produce positive outcomes. The negative effect observed here suggests that career progression systems may be weakly linked to performance outcomes or may create administrative or motivational inefficiencies when not supported by broader workforce development mechanisms.

Gender inclusion shows a positive and statistically significant effect on operational efficiency in the absence of interaction effects, suggesting that increasing gender inclusion contributes to improved operational outcomes in the maritime transport industry. This finding is consistent with Ogbulu *et al.* (2024), who indicate that well-implemented human capital strategies can enhance organizational performance. It also aligns with Obeng Tuaah (2025), who reports that inclusive workforce development strategies contribute to improved productivity and innovation across industries. However, the positive effect appears conditional,

as it may depend on how well institutions and workforce systems operationalize gender inclusion, rather than automatically driving efficiency.

Workforce diversity also shows a positive and statistically significant effect on operational efficiency, indicating that diverse workforce structures enhance efficiency in maritime operations. This finding is strongly supported by Aldoghan and Sundram (2023), who demonstrate that workforce composition and engagement significantly improve operational efficiency and innovation capacity. It is also consistent with Arena *et al.* (2022), who emphasize that human capital diversity and development contribute to productivity improvements. Similarly, Obeng Tuaah (2025) shows that workforce diversity, when properly managed, enhances organizational performance and competitiveness. The result therefore suggests that diversity contributes to better coordination, problem-solving, and adaptability in maritime operations.

The interaction effects show important moderating roles of workforce development. The interaction between skills development and workforce development is positive and highly significant, indicating that workforce development strongly enhances the effectiveness of skills development on operational efficiency. This finding supports Arena *et al.* (2022), who demonstrate that training yields stronger productivity gains when embedded within broader human capital systems. It also aligns with Aniceto (2025), who emphasizes that workforce training must be integrated into structured development frameworks to improve operational outcomes. Similarly, Ogbulu *et al.* (2024) argue that training effectiveness depends on alignment with organizational strategy and support systems. This result therefore confirms that skills development becomes highly effective only when reinforced by strong workforce development structures.

The interaction between recruitment and workforce development is negative and statistically significant, suggesting that workforce development weakens recruitment's effect on operational efficiency. This may indicate that recruitment practices are not effectively integrated into workforce development systems or that over-recruitment without absorption capacity creates inefficiencies. This interpretation aligns with Moussir and Liouaeddine (2022), who show that human capital inputs do not always translate into productivity gains under structural constraints. It also reflects the caution raised by Arena *et al.* (2022), who note that external factors such as organizational capacity and technology may distort the productivity effects of workforce inputs.

The interaction between career progression and workforce development is positive and statistically significant, indicating that workforce development enhances the positive effect of career progression on operational efficiency. This finding is consistent with Aldoghan and Sundram (2023), who show that structured training and employee engagement strengthen the impact of human resource practices on efficiency. It also supports Ogbulu *et al.* (2024), who argue that career development produces better outcomes when aligned with strategic workforce planning. This result suggests that career progression becomes more effective when embedded within a broader workforce development framework.

The interaction between gender inclusion and workforce development is negative and statistically significant, suggesting that workforce development weakens the relationship between gender inclusion and operational efficiency. This may reflect implementation challenges, where inclusion policies are not fully aligned with operational or training systems. Ogbulu *et al.* (2024) emphasize that workforce interventions must be carefully designed to avoid inefficiencies, while Aniceto (2025) indicates the importance of institutional readiness in ensuring effective workforce reforms. The negative interaction therefore suggests that inclusion efforts may require better integration into workforce systems to translate into efficiency gains.

The interaction between workforce diversity and workforce development is negative but statistically insignificant, indicating that workforce development does not meaningfully alter the effect of diversity on operational efficiency. This suggests that diversity may already exert its effect independently of formal workforce development systems, consistent with Obeng (2025), who finds that diversity contributes directly to performance outcomes across industries. It may also indicate that diversity effects are structural rather than programmatically driven.

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5. Conclusion and Policy Implications

This study examined the determinants of maritime workforce development in Cameroon's maritime transport industry and the moderating role of workforce development in the relationship between human resource and skills-related factors and operational efficiency. The findings show that maritime workforce development in Cameroon remains relatively low. Safety and environmental training and curriculum design are the factors most strongly associated with workforce development; the regulatory and institutional framework exerts a moderate influence, and technological integration remains markedly underdeveloped.

For operational efficiency, skills development and career progression, considered independently of workforce development, have significant negative effects, while gender inclusion and workforce diversity have significant positive effects. The interaction effects show that workforce development substantially strengthens the positive effect of skills development and career progression on operational efficiency, weakens the effects of recruitment and gender inclusion, and does not significantly moderate the effect of workforce diversity. The model is jointly statistically significant and explains a moderate proportion of the variation in operational efficiency.

From a policy perspective, maritime regulatory authorities in Cameroon should strengthen the enforcement and implementation of regulatory and institutional frameworks governing maritime training, rather than focusing solely on their formal existence, given that workforce development outcomes have not kept pace with the relatively high presence of regulatory structures. Maritime training institutions should prioritize redesigning and continuously reviewing curricula, since this study identified curriculum design as one of the strongest determinants of workforce development. The Ministry of Transport and relevant maritime authorities should significantly increase investment in technological integration within maritime training institutions, given that technological integration recorded the lowest level among all workforce development determinants examined. Maritime training institutions should expand and standardize safety and environmental training programs across all institutions, given their strong association with workforce development outcomes, while addressing the current unevenness across institutions. Maritime transport operators and port authorities should not implement skills development and career progression programs as standalone interventions, since both can negatively affect operational efficiency without strong workforce development systems; instead, they should embed these interventions within broader workforce development structures to realize their potential benefits. Human resource departments in maritime transport and port institutions should review recruitment practices to ensure hiring is matched by adequate absorption capacity, training support, and integration into existing workforce systems, since weak workforce development can weaken recruitment's effect on operational efficiency rather than strengthen it.

6. Limitations and Direction for Future Research

Despite its contributions, this study has several limitations that readers should consider when interpreting its findings. The study adopted a cross-sectional research design, with data collected from respondents at a single point in time. While this design is appropriate for examining associations and moderating relationships among the study variables, it does not permit firm conclusions regarding causality. The relationships identified between regulatory and institutional framework, curriculum design, technological integration, and safety and environmental training, on the one hand, and maritime workforce development, on the other, as well as the moderating role of workforce development in the relationship between skills development and related institutional factors and operational efficiency, should therefore be interpreted as associations observed at a given point in time rather than as evidence of causal effects that unfold over time.

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Appendix

RESEARCH INSTRUMENT

Your participation is voluntary, and your responses will be kept confidential and used only for research purposes.

A. DEMOGRAPHIC CHARACTERISTICS OF SMALLHOLDER FARMERS

[1] What is your sex? [a] Male [b] Female
[2] What is your level of Education? [a] No Education [b] Primary [c] Secondary [d] Tertiary Education
[3] In which age group are you? [a] < 25 years [b] 25 – 35 [c] 35 – 45 [d] > 45
[4] What is your marital status? [a] Single [b] Married
[5] How many years have you been working in the organization? [a] < 5 years [b] between 5–10 years [c] >10 years

SECTION B: Maritime Education and Training

Sir/Madam, please kindly reply to the following statements by ticking where appropriate. Strongly disagree (1) Disagree (2) Neutral (3) Agree (4) Strongly agree (5)

	Regulatory and Institutional Framework	**1**	**2**	**3**	**4**	**5**
6	The maritime schools follow recognized national and international maritime regulations.					
7	Institutional rules and academic policies are clearly communicated to students during training.					
8	The training program complies with maritime standards such as STCW.					
9	Regulatory requirements relevant to maritime operations are well explained to trainees.					
10	The institution provides adequate guidance on professional and ethical conduct in maritime work.					
11	The institution's regulatory framework prepared me to comply with port and maritime regulations.					
	Curriculum Design					
12	The maritime training program curriculum is structured and logically organized.					
13	Course content is relevant to real port and maritime operational activities.					
14	The curriculum matches the skills required for port jobs.					
15	The course strikes an appropriate balance between theoretical knowledge and practical learning.					
16	Course content is updated to reflect changes in the maritime industry.					
17	The curriculum adequately prepares students for operational challenges in port work.					
	Technological Integration in MET					
18	The maritime school used modern training equipment and technological tools.					
19	Training on digital and automated systems relevant to maritime operations is received.					
20	Simulation tools demonstrate real-life maritime and port scenarios.					
21	Technology-based training helped students adapt quickly to port operational systems.					
22	Technology enhances students' understanding of maritime operations.					
23	Training prepares learners to work with modern equipment used at the port.					
	Safety and Environmental Training					
24	Maritime training included comprehensive instruction on occupational safety.					
25	Safety procedures are clearly taught during my training program.					
26	Training on emergency response and accident prevention is received.					
27	Training emphasizes environmental protection and pollution control.					
28	Safety and environmental training prepared learners to handle risks at the port.					
29	The training improved learners' awareness of environmental responsibilities in maritime operations.					

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SECTION C. Maritime Workforce Development

Sir/Madam, please kindly reply to the following statements by ticking where appropriate. Strongly disagree (1) Disagree (2) Neutral (3) Agree (4) Strongly agree (5)

	Skills Development	1	2	3	4	5
30	My job at the port allows me to continuously develop my professional skills.					
31	On-the-job learning improves my work performance.					
32	I am given opportunities to acquire new skills relevant to port operations.					
33	Supervisors and management encourage skill development.					
34	Improved skills help me perform my duties more efficiently.					
35	Skills development initiatives enhance my adaptability to operational changes.					
	Recruitment					
36	Recruitment at this port is based on relevant qualifications and skills.					
37	The recruitment process is transparent and clearly communicated.					
38	Job requirements are clearly stated during recruitment.					
39	Workers are recruited based on merit rather than personal connections.					
40	Recruitment practices ensure competent personnel are employed.					
41	Proper recruitment improves overall operational performance at the port.					
	Career Progression					
42	This port has clear promotion and advancement pathways.					
43	Performance is considered when making promotion decisions.					
44	Career progression opportunities motivate me to work harder.					
45	The port provides guidance on career development and advancement.					
46	Promotion processes are fair and objective.					
47	Career progression contributes to long-term employee commitment.					
	Gender Inclusion					
48	Men and women have equal employment opportunities at this port.					
49	Gender does not limit access to operational or technical roles.					
50	Promotion opportunities are equally available to all genders.					
51	The port provides a work environment free from gender discrimination.					
52	Gender inclusion policies are respected in daily port operations.					
53	Gender equality improves teamwork and organizational performance.					
	Workforce Diversity					
54	The port workforce includes employees from diverse backgrounds.					
55	Diversity is respected and valued in the workplace.					
56	Workers from different backgrounds collaborate effectively.					
57	Management promotes inclusiveness among all categories of workers.					
58	Workforce diversity enhances problem-solving and innovation.					
59	A diverse workforce contributes to improved port performance.					

SECTION D: **Operational Efficiency**

Sir/Madam, please kindly reply to the following statements by ticking where appropriate. No (1) Yes (2)

	Operational Efficiency	**No**	**Yes**
60	Port operations are carried out in an organized and efficient manner.		
61	Adequate worker training contributes to faster, smoother port operations.		
62	Decisions are made promptly to avoid operational interruptions.		
63	Modern equipment improves efficiency in port operations.		
64	Clear operational procedures help me perform my tasks efficiently.		
65	Effective communication among port workers improves overall operational performance.		

Thank you for your cooperation!!!

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