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Logistics Planning Performance Model for Improving Offshore Operations in the Gulf of Guinea

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Abstract: This paper aims to develop a model for measuring logistics performance using logistics planning variables. Principal component analysis and structural equation modeling were applied to evaluate data from a sample of 360 senior/middle managers working in various offshore logistics companies, randomly selected from among Nigerian logistics workers. The results show that logistics planning positively impacts profitability by strengthening disaster resilience and business continuity procedures. Additionally, the research indicates that a company can maintain both efficiency and risk management by implementing effective planning procedures, which are a crucial component of logistics planning. Logistics service providers involved in offshore operations should pay close attention to the following: identifying emergency contacts for logistics-related incidents, assessing the level of risk that the company can tolerate in its logistics operations, determining when to revisit continuity plans for logistics processes, evaluating these continuity plans effectively, ensuring adequate training for employees involved in their preparation, earnings before taxes with competitors, and tracking the pace of recovery from disruptions relative to competitors.

Keywords: Logistics, performance model, competitive abilities, logistics service providers and offshore

1. Introduction

To ensure the efficient and successful transfer of resources and commodities to remote offshore areas, oil and gas companies offshore operations require intricate logistical planning. Nevertheless, comprehensive performance models specifically designed to evaluate the results of logistics planning techniques are scarce. Therefore, the way logistics planning is currently assessed in offshore operations might not adequately reflect the unique challenges and demands of the oil and gas sector. Thus, it is necessary to develop a performance model that can precisely quantify and analyze the impact of logistics planning on offshore operations in this industry. This study attempts to address this gap by developing a robust performance model that can provide valuable insights into the effectiveness of logistics practices.

However, research on logistics planning is still in its infancy, which suggests a dearth of literature addressing contingency planning in supply chain management. Important issues concerning the relationship between financial performance, operational capabilities, and company continuity remain unresolved despite this recent work. Moreover, existing theoretical frameworks specifically fail to explain the trade-offs involved in balancing risk mitigation with the preservation of organizational efficiencies in intricate supply chains.

Additionally, a facility's level of exposure to external risks and calamities, as well as its fiscal sustainability, determines the significance of logistics support for that facility. Offshore operations have been plagued by some of the common accident hazards such as the release of crude oil from subsea wells, pipelines, jumpers and flow lines, the release of crude oil from production risers, the release of crude oil from FPSO (floating production, storage, and offloading vessels) hydrocarbon process plants, the release of crude oil during cargo offloading operations, the release of gas from FPSO hydrocarbon process plants, the release of gas from export and gas injection risers, ignition of VOC (volatile organic compounds) gases in the crude oil tank, the release of gas from the inert gas generator fuel gas supply system, the release of crude oil from crude oil tanks, the release of methanol, failure of the FPSO mooring arrangement, vessel impact with FPSO, failure of topside support structures, and hull structure failure, among many others.

To prevent these, spare parts must be supplied from onshore locations, necessitating smart logistics planning. If any of these fail, the entire asset might be destroyed or suffer significant damage that would cost millions of dollars to repair. In this instance, the study will look into the significance of logistics planning, which can be defined as the application of planning concepts to supply chain logistics in offshore locations to prevent any of the issues listed above.

A major offshore oil and gas operations hub, the Gulf of Guinea requires efficient logistics planning to maximize operational performance, reduce expenses, and guarantee project completion on schedule. The logistics function represents a visibly concentrated supply chain function that is of principal importance to managers [1]. A framework aimed at optimizing fleet and vessel operations in the oil and gas industry was developed by [2]. According to the study, emphasis is placed on integrated operations planning and efficiency optimization. [3] examined how digital logistics management systems could improve the effectiveness of human transportation for offshore workers, optimize accommodations, and coordinate the arrival of staff and equipment to offshore locations.

The impact of a Ghanaian oil exploration company's logistics planning on organizational performance was assessed by [4]. It was discovered that good logistics planning practices, such as careful product inspection and purchase order compliance, greatly improve organizational performance. Logistics planning plays a crucial role in reducing operational difficulties during offshore well drilling [5]. The report highlights that ineffective logistics, such as delayed equipment shipments and inadequate staff mobilization, can result in costly downtime and project delays. In their study of Nigeria's marine infrastructure, [6] focused on the infrastructure's ability to facilitate offshore transportation and installation operations. The study stressed the need to evaluate local resources, such as equipment, skilled labor, and vessel availability, in order to maximize offshore operations in Nigeria.

2. Literature Review

A hub for offshore operations, the Gulf of Guinea is an area rich in gas and oil resources, particularly for nations like Ghana, Angola, and Nigeria. To ensure operational effectiveness and reduce risks arising from the region's specific difficulties–such as piracy, legislative inconsistencies, and inadequate infrastructure–effective logistics planning is essential in the Gulf of Guinea. Offshore logistics refers to the management of supply chain operations supporting exploration, production, and maintenance activities at oil and gas sites. Logistics planning is a crucial factor in determining operational performance, as the Gulf of Guinea is home to many offshore oil installations and vessels. According to the literature, the complexity of offshore logistics stems from the need to coordinate multiple activities, including the transportation of people, supplies, and equipment to offshore sites under strict safety and schedule requirements [7].

According to [8], the increasing frequency and significant impact of disasters have prompted businesses and their supply chain organizations to develop capabilities aimed at mitigating their adverse impacts. Disasters, whether natural or man-made, are unpredictable and create significant uncertainty for affected companies. Organizations must search for and apply information embedded within their supply chains to respond promptly to crises and emergencies triggered by various disaster types [9]. During an emergency, managers must make decisions based on available information and attempt to reconcile conflicting sources of information. Due to the lack of complete information about the event and its ramifications, as well as the extreme time constraint to make a decision, these decisions are extremely difficult [10]. According to [11], a company's ability to successfully extract knowledge from its supply chain and translate it into actionable strategies is crucial for crisis management in such situations.

The application of logistics planning procedures for risk management is a relatively new area of study within supply-chain research [12-14]. A paradigm for risk mitigation that links risk management to a firm's core competencies has been developed by conceptual research, grounded in logistics planning principles [14]. Similarly, [15] emphasized the significance of information technology in the logistics planning process.

Logistics planning frameworks were defined and operationalized by logistics companies. Findings from functional-level research have been hard to extrapolate to the broader organizational context due to a lack of confirmatory research. Only few studies have addressed the wider effects of logistics planning in supply chains. To advance this research, a comprehensive empirical evaluation of the relationship between logistics planning and organizational performance is specifically necessary. By employing a survey-based research design, this study addresses a key gap in the literature gap by examining the interconnections between FINP, operating capacity, and logistical planning.

Security risks in the Gulf of Guinea remain high, with piracy continuing to pose a serious threat. According to the International Maritime Bureau, 95% of all maritime kidnapping incidents worldwide in 2021 occurred in the Gulf [16]. This has an impact on vessel movement and increases the cost of security measures like armed escorts and higher insurance premiums significantly [17]. As for the deficiencies in infrastructure, the region's ports sometimes lack the modern facilities required for efficient offshore logistics. For example, supply chain timeframes are impacted by congestion and delays in Nigerian ports. The tropical climate of the area causes unpredictable weather patterns, which in turn affect operational safety and vessel scheduling. In the Gulf of Guinea, predictive analytics and advanced vessel monitoring systems remain underutilized, despite their widespread deployment in other regions [18].

In some offshore areas, such as the North Sea, the use of digital tools like real-time tracking and Vessel Traffic Management Systems (VTMS) has shown promise. By improving supply chain visibility and optimizing routing, these solutions reduce delays and enhance operational safety [19]. Frameworks for collaborative security have emerged: States from the Gulf of Guinea signed the Yaoundé Code of Conduct to foster regional cooperation in the fight against illegal activity and piracy. Joint naval patrols and information-sharing systems have demonstrated the potential to reduce security threats [17]. To ensure the effectiveness and sustainability of logistics operations, it is important to allocate more resources to the training of local staff. For instance, Brazilian offshore activities in the Campos Basin illustrate how tailored training initiatives have strengthened local capabilities and reduced dependence on foreign workers [7].

With its robust technological adoption and effective regulatory frameworks, North Sea operations serve as an example of efficient offshore logistics. Key lessons from the region include the use of integrated logistics centers and the alignment of public and private sector objectives [18]. To manage its extensive network of offshore operations, the Gulf of Mexico relies on centralized planning systems and cutting-edge logistical platforms. Similar innovations could enhance the efficiency of Nigerian offshore logistics by increasing productivity and reducing operational costs.

Improving regional cooperation and implementing cutting-edge surveillance technologies can help reduce the risk of piracy. Existing infrastructure deficiencies can be addressed by making investments in modern port infrastructure and offshore hubs. Implementing eco-friendly practices, such as the use of low-emission vessels, not only lowers operating costs but also ensures compliance with international standards. Regulatory frameworks across the Gulf of Guinea countries should be harmonized to facilitate cross-border operations. Effective logistics planning for offshore activities in the Gulf of Guinea requires a comprehensive strategy that addresses infrastructure, environmental, and security challenges. Through the adoption of global best practices and leveraging regional capabilities, stakeholders can improve the offshore industry's sustainability and efficiency.

3. Data and Methods

The study employed purposive open sampling due to the ease of identifying suitable participants within the target population. A total of 360 senior and mid-level management staff from various offshore locations were arbitrarily taken from the Nigerian offshore workers. These individuals were surveyed using a Google Forms questionnaire, which focused on their understanding of Safety Leading and Lagging Indicators Performance, which included but was not limited to the following indicators (see Fig. 1):

Fig. 1 Safety Leading and Lagging Indicators. Source: authors

To achieve more reliable and meaningful results for this study, both secondary and primary data were used. Primary data was collected through questionnaires that were created and administered to respondents at various offshore locations through Survey Monkey platform. The sample consisted of top and middle management staff, selected due to their familiarity with the operational and logistics functions of their organizations.

This study followed a two-step process to test the proposed research model. The SPSS 20.0 software package was used to evaluate the psychometric properties of the measurement scales. An assessment of the means of the variables and the scale items for the two groups was conducted using one-way ANOVA. In addition, pairwise correlation analysis was also performed.

The logistics planning scale was adapted from the modified model proposed by [20]. The research model consists of a 37-item multivariate scale encompassing seven variables: Knowledge of Contact Points (CP), Knowledge of Roles and Responsibilities (RR), Knowledge of Continuity Recovery Service Levels (CRSL), Development of Business Continuity Processes (BCP), Training of Personnel to Create and Execute Continuity Plans (TRAIN), Financial Performance (FINP) and Disaster Immunity (DI).

$$\textit{Logistics planning Performance Model} = f\,(CP, RR, CRSL, BCP, TRAIN, FINP, DI) \quad (1)$$

Tables 1, 2, and 3 show the characteristics of the respondents surveyed via Google Forms. The respondents are core logistics and supply chain professionals engaged in offshore operations, with 44% working in the oil and gas industries. Approximately 85.5% hold at least a first degrees, while 69.1% occupy senior/top management positions related to logistics planning.

Table 1 Organizations Surveyed. Source: authors

	Freq.	%	Valid %	Cum. %
Logistics Firm	73	20.3	20.3	20.3
Manufacturing Firm	42	11.7	11.7	32.0
Oil and Gas	158	44.0	44.0	76.0
Supply Chain Operations	49	13.6	13.6	89.7
Transport Firm	37	10.3	10.3	100.0
Total	359	100.0	100.0	

Table 2 Educational qualification of respondents. Source: authors

	Freq.	%	Valid %	Cum. %
HND/BSc/B.Eng./B.Tech	198	55.2	55.2	55.2
MSc/MBA	104	29.0	29.0	84.1
NCE/ND	16	4.5	4.5	88.6
PhD	41	11.4	11.4	100.0
Total	359	100.0	100.0	

Table 3 Staff Cadre. Source: authors

	Freq.	%	Valid %	Cum. %
Junior staff	32	8.9	8.9	8.9
Middle-level manager	79	22.0	22.0	30.9
Senior manager	39	10.9	10.9	41.8
Senior staff/Supervisor	209	58.2	58.2	100.0
Total	359	100.0	100.0	

4. Results and Discussion

4.1 Analysis of Logistics Planning Strategies in Offshore Operations

Table 4 presents the results of the reliability analysis. All the values of reliability test exceed the threshold value of 0.70, indicating acceptable internal consistency and confirming the scale reliability.

Table 4 Reliability Test. Source: authors

Cronbach's Alpha	No. of Items
.983	38

We examined each scale's discriminant and convergent reliability to ensure overall scale validity. Convergent validity is demonstrated when all first-order factor loadings are significant for the second-order factors and when items load substantially on their respective constructs. All corresponding components were highly significant at $p<0.001$, as shown in Table 6. This applied both to the loadings of the first-order factors on the second-order factors and to the item loadings on their respective first-order factors. Moreover, all loading values exceeded 0.60, further supporting the convergent validity of the scales.

Table 5 Summary of canonical discriminant functions. Source: authors

Eigenvalues				
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	49a	76	76	.990
2	15a	24	100	.969

Table 6 Wilks' Lambda. Source: authors

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	.001	1516	8	.000
2	.061	631	3	.000

Discriminant validity of the scales was assessed using Wilks' Lamda. In this analysis, the fixed model constrains the correlation between constructs to 1, whereas in the free model, correlations are freely estimated. Discriminant validity can be evaluated through pairwise comparisons or an omnibus test, which examines all constructs simultaneously. A significant χ^2 difference between the fixed and free models ($\Delta\chi^2 = 1515.854$, $p < 0.001$) indicates that the free model provides a better fit. Additionally, the free model demonstrates superior fit indices compared to the fixed model. Pairwise comparisons presented in Table 5 further confirm that the free model fits the data significantly better than the fixed model. These results provide strong evidence supporting the discriminant validity of the construct scales.

The measurement model was subsequently evaluated, showing acceptable fit indices ($\chi^2 = 631.458$, $p < 0.001$). In summary, the analyses presented provide sufficient confirmation of both discriminant and convergent validity of the scales.

4.2 Test of the Causal Structure of Variables of Logistics Planning Strategies in Offshore Operations

Table 7 χ^2 Test Statistics. Source: authors

	CP1	CP2	CP3	FINP1	FINP2	FINP3	FINP4	DI1	DI2	DI3	D14
Chi-Square	217.504[a]	89.008[a]	176.613[a]	96.474[a]	53.214[a]	111.515[a]	49.287[a]	94.835[b]	50.958[a]	78.284[a]	94.691[a]
df	4	4	4	4	4	4	4	4	4	4	4
Asymp. Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

The $\chi2$ test is used to evaluate the relationship pattern within the performance model. First, model fit indices were applied to assess the entire model construct. The causal fit indices (for example, FINP1 $\chi2 = 96.474$, $p<0.001$) met the accepted thresholds for satisfactory model fit. Furthermore, based on the Kruskal Wallis test, the performance model demonstrate a statistically significant difference when compared to the LP model ($\Delta\chi^2 = 3.190$, $p>0.001$), suggesting that the proposed model does not adequately capture the covariance structure of the statistics. (Table 8)

Table 8 Kruskal Wallis Test Statistics. Source: authors

	CP1	CP2	CP3	FINP1	FINP2	FINP3	FINP4	DI1	DI2	DI3	D14
Kruskal-Wallis H	6.069	6.357	4.508	3.190	6.417	2.815	3.181	2.214	4.592	5.325	4.638
df	4	4	4	4	4	4	4	4	4	4	4
Asymp. Sig.	.194	.174	.342	.527	.170	.589	.528	.697	.332	.256	.327

The direct properties of the LP model were examined using the best model statistics (Table 9). H_1, which states that logistics planning has a favorable effect on DI1 in offshore activities, was supported ($\beta=0.841$, $p<0.001$). H_2 ($\beta=-0.822$, $p<0.001$), which asserts that logistics planning helps BCP1 in offshore operations, was not supported. H_3, which claims that in offshore operations, BCP5 negatively affects LP, was sustained ($\beta=-0.751$, $p<0.001$). Likewise, H_4, indicating that DI2 benefits LP, was also validated ($\beta=1.196$, $p<0.001$). Finally, H_5, which claims that DI3 improves LP, was not as strongly supported ($\beta=-0.262$, $p<0.001$).

Table 9 Best Model Statistics Coefficients. Source: authors

	Unstandardized Coefficients		Standardized Coefficients			
	B	Std. Error	Beta	Std. Error	T	Sig.
(Constant)	3.730	.038			97.091	.000
BCP1	-1.000	.008	-.822	.006	-128.046	.000
BCP5	-.746	.008	-.751	.008	-90.678	.000
DI1	1.000	.009	.841	.007	117.131	.000
DI2	1.254	.011	1.196	.011	110.163	.000
DI3	-.254	.006	-.262	.006	-44.352	.000

Lastly, the effects of the variables in the performance model (FINP, BCP, and DI) were examined (Table 10). These three variables were included, as each was hypothesized to influence DI, BCP, and FINP, respectively. None of these control variables had a statistically significant effect, suggesting that spare resources might not contribute to disaster immunity.

Table 10 Paired Samples Correlations. Source: authors

		N	Correlation	Sig.
Pair 1	LP & BCP1	359	.028	.597
Pair 2	LP & BCP2	359	.024	.644
Pair 3	LP & BCP3	358	.063	.234
Pair 4	LP & BCP4	356	.029	.588
Pair 5	LP & BCP5	358	.033	.531
Pair 6	LP & BCP6	358	-.002	.968
Pair 7	LP & BCP7	357	-.029	.582
Pair 8	LP & BCP8	359	-.010	.846
Pair 9	LP & BCP9	359	.002	.975
Pair 10	LP & FINP1	359	-.017	.751
Pair 11	LP & FINP2	359	-.059	.264
Pair 12	LP & FINP3	359	-.044	.406
Pair 13	LP & FINP4	359	-.022	.683
Pair 14	LP & DI1	357	-.006	.906
Pair 15	LP & DI2	359	-.011	.839
Pair 16	LP & DI3	359	-.009	.867
Pair 17	LP & D14	359	-.003	.951

Table 10 shows very weak or negligible linear relationships between LP and all other indicators across BCP, FINP, and DI. This implies that the current level of logistics planning in the Gulf of Guinea does not significantly correlate with business continuity, financial performance, or disaster immunity. In particular, logistics planning shows very weak and non-significant negative correlations with all the parameters of financial performance, suggesting that logistics planning is not directly related to financial outcomes. However, the correlations between LP and DI parameters are all negative and close to zero, indicating a non-existing relationship in the research data.

4.3 Factor Analysis of Key Drivers of Logistics Planning in Offshore Operations

The result of the Kaiser-Meyer-Olkin (KMO) test of sampling adequacy shown in Table 11 indicate a high level of partial correlation among variables, with a KMO value of 0.903. This suggests that the logistics planning dimensions are suitable for forecasting how logistics planning will affect offshore operations. The alternative hypothesis that the correlation matrix is equally an identity matrix was also accepted, agreeing to Bartlett's test of sphericity. The logistics strategies dimension is helpful for the factor analysis, as demonstrated by the $\chi2$ value of 8119.028 with a significance of 0.000, which was determined by Bartlett's sphericity test. Therefore, the logistics planning constructs - Knowledge of Contact Points (CP), Knowledge of Roles and Responsibilities (RR), Knowledge of Continuity and Recovery Service Levels (CRSL), Development of Continuity Processes, Training of Employees to Create and Execute Continuity Plans (TRAIN), Financial Performance (FINP) and Disaster Immunity (DI)) are valid indicators of logistics planning in offshore operations.

Table 11 KMO and Bartlett's Test. Source: authors

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.903
Bartlett's Test of Sphericity	Approx. Chi-Square	8119.028
	df	666
	Sig.	.000

a. Only cases for which LP = 5 are used in the analysis phase.

The researchers identified seven key dimensions of logistics planning: Knowledge of Contact Points (CP), Knowledge of Roles and Responsibilities (RR), Knowledge of Continuity and Recovery Service Levels (CRSL), Development of Continuity Processes, Training of Employees to Create and Execute Continuity Plans (TRAIN), Financial Performance (FINP) and Disaster Immunity (DI). For each dimension, the variable with the highest factor loading was identified as the most significant indicator of that logistics planning component.

Table 12 Most significant variable in the logistics planning dimension of offshore operation. Source: authors

S/No	Logistics Planning Dimensions	Most important variable	Factor loading
1	Knowledge of Contact Points (CP)	Knowledge of the contact person during an emergency CP3	0.823
2	Knowledge of Roles and Responsibilities (RR)	Understanding the level of that is tolerable RR4.	0.718
3	Knowledge of Continuity and Recovery Service Levels (CRSL)	The firms review continuity plans for its logistics operations CRSL6	0.885
4	Development of Business Continuity Processes BCP	Formulation the testing requirements for the BCP9	0.728
5	Training of Employees to Create and Execute Continuity Plans (TRAIN)	Adequate training of personnel for BCP for its logistics TRAIN1	0.704
6	Financial Performance (FINP)	Income before tax match with competitors FINP4	0.837
7	Disaster Immunity (DI))	Business units improve after disasters likened with competitors DI2	0.919

Among other variables with significant loadings in the rotated component matrix for the dimensions of Offshore Logistics Planning, logistics service providers in offshore operations should pay close attention to the following factors: Awareness of whom to contact in an emergency, the acceptable risk threshold during logistics operations, when to re-examine continuity plans for logistics, testing requirements for the BCP for logistics operations, re-training of personnel preparing BCP, income before tax in comparison with competitors (FINP4) and the ability of the business unit to recover quickly from disasters relative to competitors.:

5. Conclusion

This paper has provided the first first-hand assessment of the relationship between logistics planning and a company's FINP. It demonstrates how conscious planning processes, which are part of logistics planning, affect FINP by shaping operational routines (BCP) and DI formed within the business continuity process. By applying the principles of logistics planning, firms can enhance service quality and build disaster immunity (DI), which significantly improves their financial performance. Thus, by establishing logistics planning as a dynamic capability, this study supports the view that businesses can gain a competitive edge through adaptation to environmental challenges.

This paper has several implications for managers. First, logistics managers must structure their organization in ways that buffer logistics operations against disruptions. We propose that decision-making authority be decentralized to those managers or strategic partners who possess the most situational knowledge. To this end, efforts should be made to define clear roles and responsibilities for all individuals involved in supply chain and business operations. Second, there are important implications for human resource management, specifically in the allocation of resources toward the proper training of employees in disaster and disruption prevention activities. Training should involve not only technical skills for developing failure prevention and recovery plans, but also interpersonal skills needed to improve a firm's business logistics continuity performance. Third, our findings underscore the importance of cultivating a sound organizational working environment in offshore operations.

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