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The Impact of Green Maritime Logistics in Enhancing the Operational Performance of Iraqi Oil Ports

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ABSTRACT

The paper aims to evaluate the impact of green maritime logistics activities on operational performance in Iraqi oil ports affiliated with Basra Oil Company. The paper reviewed a set of previous studies related to the application of green indicators in maritime port logistics. Several problems were identified through a checklist distributed to selected employees in Iraqi oil ports. The study relied on a descriptive-analytical approach for a sample of 276 employees, where data were collected via a questionnaire and analyzed using (AMOS V.24 – JASP V.19) programs. The results showed a positive impact relationship and a statistically significant correlation between green maritime logistics activities and operational performance of 37%. The results also revealed that both safety and security codes and green environmental sustainability had strong positive impacts on operational performance, contributing 36% and 37% of the variance, respectively. While logistics coordination and integration and supporting maritime units showed moderate impacts of 29% and 27%, respectively. Information systems had a smaller impact on operational performance, at 3.4%. The most important conclusions that the paper comes up with are that incorporating green practices contributes to reducing pollution in Iraqi oil ports, and green maritime logistics boosts operational performance and fostering awareness.

1. INTRODUCTION

Logistics refers to a set of procedures and activities related to supply chain management, focusing on the efficient and economical distribution, transportation, and warehousing of goods. It also encompasses the planning, organization, and management of the flow of goods from their origin to their final destination. Historically, logistics originated from the need to optimize military supply chains and logistical support during periods of conflict.

Over time, logistics concepts and practices have permeated the corporate sector, becoming a fundamental aspect of contemporary business administration. Logistics has evolved into a specialized discipline, leveraging information technology and operations management systems to optimize efficiency and integrate supply chains [1]. Maritime logistics, in particular, refers to the organization, planning, and execution of activities related to the distribution and transportation of goods via sea routes. This field encompasses the management of all aspects of marine operations, including shipping, transportation, storage, and unloading, to enhance the efficiency and reliability of maritime supply chains. Key components of maritime logistics include maritime transport management, port and harbor management, international maritime logistics coordination, inventory control, warehousing, and ensuring marine safety and security [2].

Crude oil logistics is the critical mechanism for delivering crude oil to ports, playing a pivotal role in ensuring a steady supply of petroleum products to markets. This process is highly sensitive to fluctuations in product demand, crude oil prices, and environmental regulations. Studies have shown several challenges that are likely to occur by 2050, most notably the increase in greenhouse gas emissions from maritime transport, including logistics operations, by 250% from their 2012 level of 796 million tons of carbon dioxide, in addition to harmful organisms transported through ballast water, which pose a major environmental threat and a danger to fish populations, in addition to the above, there is another threat, which is documented oil emissions and spills [3]. Therefore, the adoption of green logistics services, which focus on improving energy efficiency, is essential to mitigate greenhouse gas emissions from maritime logistics activities, including those related to crude oil logistics [4]. Historically, emissions from ports and maritime operations have been largely ignored. However, the Exxon Valdez disaster in Alaskan waters, which led to MARPOL (Marine Pollution Control) and the eventual phase-out of single-hulled oil tankers, is a landmark event in oil spill disasters [5]. In response, many nations have since introduced stringent policies and practices under the "green port" initiative, aiming to achieve environmental sustainability while reducing emissions, oil spills, and associated risks.

Green logistics activities contribute to reducing environmental impact through several methods, the most important of which is reducing emissions and improving fuel efficiency in a way that reduces greenhouse gas emissions such as carbon dioxide. It also contributes to reducing dependence on fossil fuels, which leads to reducing pollution resulting from fuel combustion. In addition to its contribution to waste management by focusing on recycling processes that help reduce environmental pollution resulting from waste. The concept of operational performance encompasses the quantifiable factors that ensure the effectiveness of an organization's operations, including inventory management, production cycle times, and reliability. It reflects an organization's capability to execute strategic operations that drive the achievement of its overarching goals and performance metrics [6]. Operational performance integrates business performance indicators that influence market share and customer satisfaction through the implementation of performance measurement systems, serving as a tool for regulatory oversight and monitoring. Furthermore, core performance measurement tools are vital for every organization, acting as predictive indicators that assist management in forecasting the company's financial standing and future prospects [7].

The researchers structured the study methodology by focusing on the independent variable of green maritime logistics activities, encompassing five key dimensions: information systems, security and safety codes, green environmental sustainability, logistics integration coordination, and the support of maritime units. The dependent variable, operational performance, was analyzed through three critical dimensions: energy efficiency, human resources, and port infrastructure. All dimensions for both independent and dependent variables were derived from the green port checklist and established literature. The research seeks to answer the following question: To what extent does the application of green maritime logistics enhance the operational performance of Iraqi oil ports and the maritime units operating within them?

2. CHALLENGES FACING OIL PORTS

With over 80% of global goods being transported by sea, ports play a pivotal role in the economic and social development of nations. They serve as critical hubs that sustain the economies of many countries, especially developing ones [8]. Oil ports, as a fundamental part of the global logistics network, enable the safe transportation and distribution of crude oil and its derivatives across international waters. Given their crucial role in ensuring fuel and energy supplies for numerous nations and regions worldwide, oil ports hold significant strategic importance [9].

Despite the vital and beneficial role oil ports serve, they are also recognized as significant contributors to environmental and public health risks due to the logistical operations conducted within them. A major concern stems from emissions produced by marine units and oil ports. Shipping operations, in particular, account for approximately 15% of global nitrogen oxide emissions and 5% to 8% of sulfur oxide emissions. In response to these environmental concerns, a new maximum limit for sulfur content in fuel was implemented in January 2015, requiring ships operating within emission control areas (ports and coastal zones) to reduce their sulfur content by 0.1% to comply with regulatory standards. This reduction was implemented with strict enforcement [10].

Given the first author role as a member of one of the key and supportive departments within the oil ports, he possesses extensive knowledge and familiarity with many of the critical issues and operational aspects related to the Iraqi oil ports and the maritime vessels operating within them. Iraqi oil ports are considered among the most important vital facilities in the country's oil sector, as they play a fundamental role in exporting crude oil to global markets. These ports include Basrah Oil Port, Al-Khor Oil Port, Umm Qasr Oil Port and Al-Amaya Oil Port as well as SPM floating platforms that have been equipped to export large quantities of oil. The specific characteristics of Iraqi oil ports include specialized infrastructure for storing and transporting oil, in addition to the fact that most ports are located in deep waters that allow receiving large oil tankers. However, these ports suffer from challenges related to modernizing environmental facilities and technologies, as they need to improve operational efficiency and reduce the environmental impacts resulting from oil loading and unloading operations.

One of the most significant limitations faced by the study is the difficulty to some extent in obtaining data related to the problems facing oil ports, as most of this information is considered confidential and is kept within a narrow circle of stakeholders. This confidentiality represents a major challenge in obtaining the data needed to conduct a comprehensive analysis. There is also another major limitation related to the difficulty of generalizing the results reached to a field or environment other than oil ports, due to the uniqueness and privacy that characterize these ports in terms of infrastructure, operational processes, and associated environmental challenges, which makes transferring the results of the study to other sectors a complex matter that requires further adaptation to the different variables in those environments.

This includes a deep understanding of the activities carried out and the specific challenges they face. To further explore the difficulties and challenges directly linked to the operational environment of Iraqi oil ports, the researcher conducted a pilot study through the development of a diagnostic checklist. This checklist comprised 25 binary questions (applied, not applied) aimed at identifying specific issues, as detailed in Appendix B. The checklist was distributed to employees working at Basra Oil Port, Al-Amaya Oil Port, and SPM floating platforms, as well as marine vessels owned by the Basra Oil Company. The study included 100 employees across various administrative and technical levels.

The results of the survey study supported the researcher's initial observations regarding the issues and challenges within the Iraqi oil ports. Consequently, the research problem can be articulated by asking the following question: To what extent do green maritime logistics influence the operational performance of Iraqi oil ports and the marine units operating within them? Additionally, do green maritime logistics activities play a role in this impact?

3. HYPOTHESIS FRAMEWORK AND STUDY DESIGN

As shown in Figure 1, this study examines the theoretical framework that links green maritime logistics activities to operational performance. The framework explores the key dimensions of both constructs, including energy efficiency, human resources and port infrastructure for operational performance, information systems, security and safety codes, green environmental sustainability, logistics coordination and integration, and marine units support for green maritime logistics services that aim to address emission-related issues, improve operational performance and increase competitiveness. The hypotheses developed in this research aim to explore the statistically significant relationships between these variables, which contribute to enhancing sustainability, handling efficiency, logistics, delivery times, and customer satisfaction through indicators such as vessel turnaround time and handling speed, as shown in Figure 1 below.

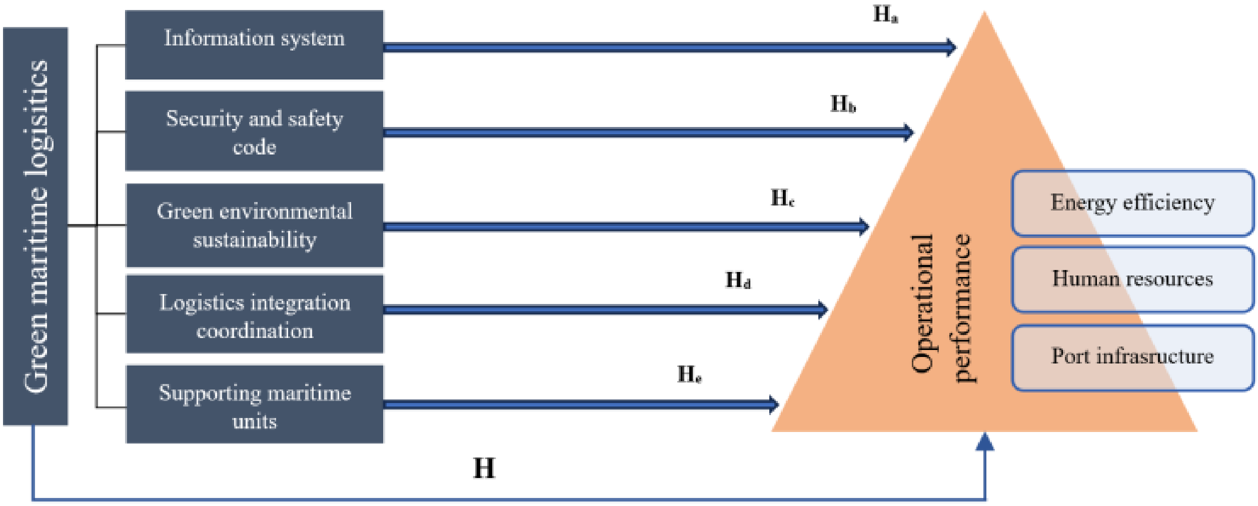

Figure 1. The outline of the hypothesis study
Source: Prepared by the researcher based on study variables

The main hypothesis (H) asserts that there is a statistically significant impact of green maritime logistics activities on operational performance. This overarching hypothesis forms the foundation for the following sub-hypotheses, each of which examines specific dimensions of green maritime logistics and their individual influence on various aspects of operational performance. These sub-hypotheses explore how key factors, such as information systems, security and safety protocols, environmental sustainability, logistics coordination, and supporting maritime units, contribute to enhancing the efficiency, sustainability, and overall effectiveness of maritime operations.

(1) H_a: There is a statistically significant relationship between information systems and operational performance.
(2) H_b: There is a statistically significant influence of the security and safety code on operational performance.
(3) H_c: There is a statistically significant influence of green environmental sustainability on operational performance.
(4) H_d: There is a statistically significant relationship between logistics coordination and integration and operational performance.
(5) H_e: There is a statistically significant influence of supporting maritime units on operational performance.

4. REVIEW OF RELEVANT STUDIES

According to the study [3], the researchers used an empirical investigation in the oil export sectors of Indonesia. Optimizing the logistics of crude oil transportation in Indonesia is the main objective of this research. According to the results, the multi-objective optimization (MOO) method was used to reduce the overall logistics costs and thus reduce CO_2 emissions, while the MCDM method was used to determine the optimal route for crude oil supply.

In a study conducted by Zhang et al. [11], the researchers highlighted the sustainable way forward for green port management. The results also showed the use of bibliometric analysis and digital innovation to improve waste disposal, improve the cargo management system and manage green ports such as the ports of Ravenna, Los Angeles and Long Beach - USA [11].

The study [12] indicated an increase in the resilience of the port system to physical challenges and helped ports understand the hybrid cyber-physical security threat and reduce port vulnerabilities, and assessed the security of port facilities for ship and port facility security (ISPS). The results led to the application of the SAURON methodology by adding digital assets to port facility security checklists and considering them as part of the ISPS assessment process, especially IT systems (hardware and software applications) and specialized IT, information and data devices.

On the other hand, the study [13] aims to achieve environmental sustainability to minimize the negative impacts of a wide range of operational and shipping activities within the port perimeter by reviewing the literature methodology on the performance and sustainability assessment of Perlea Ports. The results of the study were to contribute to expanding the comprehensive knowledge of port sustainability performance and assessment by clarifying the economic impacts and feasibility.

According to Silva et al. [14], the study focuses on improving the routing and scheduling of platform supply vessels by studying the operations in the offshore oil and gas industry by discovering and analyzing the challenges and scheduling of platform supply vessels and their impact on the efficiency of the supply chain to solve the operational logistics problems that arise in the oil and gas exploration industry - Brazil. The main results of the study are to provide a new feature-rich Milp model for the problem of interest, along with a coherent solution algorithm that uses commercial solutions.

Another study [15] discusses the importance of developing an FCNF model for routing and scheduling platform supply vessels and analyzing its impact on supply chain efficiency to reduce costs and improve operational efficiency to solve the MIR problem called COSP faced by a Brazilian oil company. The results obtained from the study are that using the FCNF model to support vessel scheduling decisions in COSP has significantly improved the quality of solutions. The researcher concluded that the model provides greater visibility for each team involved in the unloading operations and predicts the inventory level at each port for the entire planning horizon. The FCNF model avoids unnecessary costs, such as delay costs, and significantly reduces the total transportation costs for the entire fleet.

The study [16] aimed to measure and improve port performance through the application of multiple regression models to assess the operational efficiency of two Nigerian ports namely Rivers and Delta ports. The findings of the study revealed through the use of multiple regression models and secondary data from the NPA portal. After comparing the operational efficiency of two eastern ports in Nigeria, River's port was found to have higher operational efficiency than Delta port. Several factors affecting port performance were identified, such as vessel movements, turnaround time, berth occupancy and number of staff. These findings have implications for the shipping and maritime industry in Nigeria.

The study [17] emphasises the development of operational strategies that represent energy routing and scheduling of ports and ships with improved technologies related to speed, maneuvering, and sensors to solve and formulate new routing problems to reduce energy consumption and thus reduce emissions of pollutants and greenhouse gases and become more sustainable for the environment. As the results of the study showed, energy saving and emission reduction were achieved through energy management and the use of the latest technologies in addition to energy saving and emission reduction without capital investment.

On the other hand, the study [18] aims to examine the impact of training and development through training design and continuous improvement of human resources working in the port of Lagos, Nigeria. The findings confirmed the urgent need to improve the capacity of the workforce involved in using physical resources to improve performance, as well as that on-the-job training has a significant impact on the operational performance of employees in the maritime sector .

In a study conducted by Munim and Schramm [19], the researchers focused on supporting the economic growth of ports through investment in improving the quality of port infrastructure and logistics performance by improving the quality of seaport infrastructure. The results of the study confirmed that improving the quality of port infrastructure would bring the greatest benefits to the country's economy and that the quality of port infrastructure positively affects logistics performance.

5. METHODOLOGY

Regarding the selection of statistical tests, the authors selected these tests based on the nature of the data and the objectives of the study, with an emphasis on analyzing relationships and hypotheses using structural equation modeling (SEM). The authors used AMOS V.24 software to provide accurate causal analysis, and JASP V.19 software to support statistical analysis effectively.

Despite the effectiveness of the questionnaire, it faces some challenges that may affect the accuracy and reliability of the results. The most prominent of these challenges is the difficulty of reaching a representative sample of the target community, as the researcher may face difficulty in including all different categories of participants, which may lead to sample bias. In addition, answers can be influenced by personal or social biases, as participants may provide answers that conform to social expectations rather than the actual answers, distorting the data.

5.1 Study population and sample

The study sample size was determined following the guidelines presented by Sekaran and Bougie [20]. The study population comprises employees working in the oil ports and the marine vessels affiliated with the Iraqi Basra Oil Company, totaling 1,015 individuals. The researchers used the questionnaire as the main tool for collecting data in this study, while AMOS V.24 and JASP V.19 programs were used to analyze the data. The researchers relied on three statistical tests to determine the suitability of the data: the Kolmogrov-Smirnov test, the Cramer_Von Mises test, and the Anderson Darling test. When the data passes at least two of these tests, the hypothesis of normal distribution is accepted. These tests were chosen based on the nature of the data and the objectives of the study, which focus on analyzing relationships and hypotheses using SEM, where AMOS V.24 was used to conduct accurate and visual causal analyses, while JASP V.19 was used to simplify and support the statistical analysis. Despite the effectiveness of the questionnaire, it faces some challenges that may affect the accuracy and reliability of the results. The most prominent of these challenges is the difficulty of reaching a representative sample of the target community, as the researcher may face difficulty in including all different categories of participants, which may lead to sample bias. In addition, answers can be influenced by personal or social biases, as participants may provide answers that conform to social expectations rather than the actual answers, distorting the data.

As far as the sample size is concerned the authors relied on the tables indicated by Sekaran and Bougie [20] which stated that the minimum appropriate sample size for the current study is 270. Therefore, the authors distributed 325 questionnaire forms to the cadres working in the oil ports, which included all administrative and technical specializations working in the ports within the formations of Basra Oil Company, and the purpose of which was to obtain the minimum and required size of the targeted sample. The questionnaire forms were retrieved in the number 295, and a number of invalid forms were excluded due to lack of information and data, while the approved forms, which numbered 276 forms, were valid for analysis, and the response rate was more than 84.9%.

5.2 Data collection methods

The current study used the questionnaire to collect data due to its suitability for the study variables. The research questionnaire was designed based on previous studies and was distributed to a sample of 325 employees working in Basra Oil Company. 295 questionnaire forms were retrieved, and several invalid questionnaires were excluded due to a lack of information and incomplete data. As for the approved forms, which numbered 276, they were valid for analysis, and the response rate was more than 80%. The questionnaire was subjected to a set of preliminary tests to ensure its validity, reliability, and the possibility of adopting it to measure the study variables as follows:

(1) Apparent validity: Several experienced and specialized arbitrators were consulted to ensure that the scale contained enough paragraphs that measured the variables and dimensions. The necessary modifications were made to the paragraphs they indicated.

(2) Content validity: It was used to measure the reliability and stability of the sample's answers to the dimensions of the questionnaire form. Accordingly, Cronbach's coefficient was used. Based on the scale, the value of Cronbach's coefficient was higher than 0.70, which indicates good stability of the scale.

(3) Final validity test: Reliability refers to the extent of the stability of the sample's answers, and it also measures the extent of the internal consistency of the questionnaire, or the extent of the stability of the questionnaire's answers in the event that it is conducted at different times, provided that all other factors and conditions are constant.

To measure the validity of the questionnaire's statements, Spearman's correlation coefficient was used, and the results showed that the correlation relationship is strong and acceptable between each statement in the questionnaire, and that all paragraphs had a correlation coefficient greater than 0.40.

5.3 Statistical methods

The data were analyzed using JASP V.19 software (Jeffreys's Amazing Statistics Program), which was employed to compute percentages and arithmetic means. Spearman's correlation coefficient was utilized to assess the direction and strength of the relationship between the study's variables and dimensions. Additionally, AMOS V24 (Advanced Marine Operating System) was used to perform regression analysis, allowing for the determination of the direct effects of the independent variable on the dependent variable [21].

5.3.1 Test of study variables normal distribution

The normal distribution of the study variables was validated through the application of the Anderson-Darling, Cramer-Von Mises, and Kolmogorov-Smirnov tests, as presented in Table 1 below [22].

Table 1. Normal distribution test for distribution variables

Dimensions	Kolmogorov-Smirnov		Cramér-Von Mises		Anderson-Darling		Decision
	Statistic	p	Statistic	p	Statistic	p	
Information systems	0.141	<0.001	0.61	0.021	3.387	0.018	Accept
Security and safety code	0.102	0.006	0.623	0.017	3.023	0.019	Accept
Green environmental sustainability	0.09	0.023	0.023	0.035	3.692	0.007	Accept
Logistics integration coordination	0.176	0.005	0.005	0.006	3.69	0.007	Accept
Supporting maritime units	0.105	0.005	0.005	0.005	3.368	0.008	Accept
Green maritime logistics activities	0.164	0.009	0.009	0.003	3.774	0.001	Accept
Energy efficiency	0.182	0.009	0.009	0.005	3.352	0.006	Accept
Human resources	0.176	0.009	0.009	0.007	3.528	0.000	Accept
Port infrastructure	0.183	0.000	0.000	0.007	3.644	0.006	Accept
Operational performance	0.103	0.005	0.005	0.008	3.521	0.001	Accept

Table 2. Descriptive statistics and response intensity

Dimensions	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Intensity of the Answer	Answer Level
Information systems	3.869	0.464	12%	96%	High
Security and safety code	3.502	0.596	17%	86%	High
Green environmental sustainability	3.820	0.560	15%	92%	High
Logistics integration coordination	3.533	0.563	16%	88%	High
Supporting maritime units	3.882	0.582	15%	97%	High
Energy efficiency	3.323	0.612	18%	88%	Average
Human resources	3.346	0.74	22%	89%	Average
Port infrastructure	3.351	0.715	21%	90%	Average

From the results shown in Table 1 above, we can infer that the p-values ($p < 0.05$) for the Kolmogorov-Smirnov, Cramer-Von Mises, and Anderson-Darling tests indicate statistical significance. This suggests that the assumption of normal distribution for the research variables holds true, thereby supporting the validity of further statistical analyses. The acceptance of the normality hypothesis ensures that the data meet the assumptions required for subsequent parametric tests, strengthening the reliability of the study's findings.

5.3.2 Descriptive statistics

The arithmetic mean, standard deviation, coefficient of variation, response intensity, and response level values for the study variables are presented in Table 2. These descriptive statistics provide a comprehensive overview of the data distribution and variability, offering insights into the consistency and strength of responses across the variables under investigation [23].

The results presented in Table 2 indicate a strong consistency in the sample's responses to the study variables, with arithmetic means ranging between 3.351 and 3.882. Additionally, the findings demonstrate homogeneity among the sample members, as evidenced by the relatively small standard deviation values, which range from 0.464 to 0.740. The coefficients of variation, falling between 12% and 21%, further support the consistency of responses. Furthermore, the response intensity values, which range from 86% to 97%, suggest that the questionnaire's questions were formulated and that the sample members possessed a strong understanding of and interest in the study's subject matter.

5.3.3 Construct validity, confirmatory factor analysis, and fit indices for the independent variable (green maritime logistics activities)

Five key dimensions of information systems, security and safety code, green environmental sustainability, logistics integration coordination, and maritime support units—were utilized to measure the independent variable, which represents green marine logistics activities. Each dimension consists of several corresponding items. To evaluate the researcher's theoretical structural model, the factor loadings (saturation values) for each item were derived based on its associated dimension. Furthermore, the Goodness of Fit (GOF) indices were calculated to assess the model's overall fit. Table 3 presents the factor loadings for the items within the dimensions of green marine logistics activities. According to the guidelines provided by Hair Jr et al. [24], any item with a factor loading below 0.40 will be excluded from the analysis. The factor loadings for the items related to the independent variable (green marine logistics activities) As depicted in Table 3.

Table 3 presents the factor loadings (saturation values) for each item within the variable's dimensions. According to the guidelines set forth by Hair Jr et al. [24] a factor loading of greater than 0.40 between an item and its corresponding dimension is required to retain the item, indicating that it effectively measures the dimension. From the results, it is evident that the factor loadings for all items in the questionnaire exceed the acceptable threshold of 0.40. This confirms that all items are valid and should be retained, as they are integral to describing the dimensions of green maritime logistics activities.

Table 3. Saturation values of the independent variable paragraphs (green maritime logistics activities)

Factor	Indicator	Factor Loadings	Std. Error	z-Value	p
Information systems	x11	0.528	0.072	7.29	<0.001
	x12	0.558	0.086	6.482	<0.001
	x13	0.72	0.065	10.994	<0.001
	x14	0.851	0.078	10.954	<0.001
Security and safety code	x21	0.721	0.067	10.843	<0.001
	x22	0.521	0.091	5.737	<0.001
	x23	0.757	0.062	12.241	<0.001
	x24	0.695	0.057	12.234	<0.001
Green environmental sustainability	x31	0.653	0.075	8.714	<0.001
	x32	0.724	0.071	10.18	<0.001
	x33	0.857	0.066	12.9	<0.001
	x34	0.848	0.059	14.441	<0.001
	x35	0.831	0.061	13.618	<0.001
Logistics integration coordination	x41	0.873	0.062	14.122	<0.001
	x42	0.692	0.058	11.908	<0.001
	x43	0.589	0.067	8.745	<0.001
	x44	0.472	0.074	6.393	<0.001
Supporting maritime units	x51	0.486	0.079	2.367	0.018
	x52	0.743	0.056	13.257	<0.001
	x53	0.476	0.068	14.887	<0.001
	x54	0.886	0.068	13.108	<0.001
	x55	0.485	0.101	4.82	<0.001

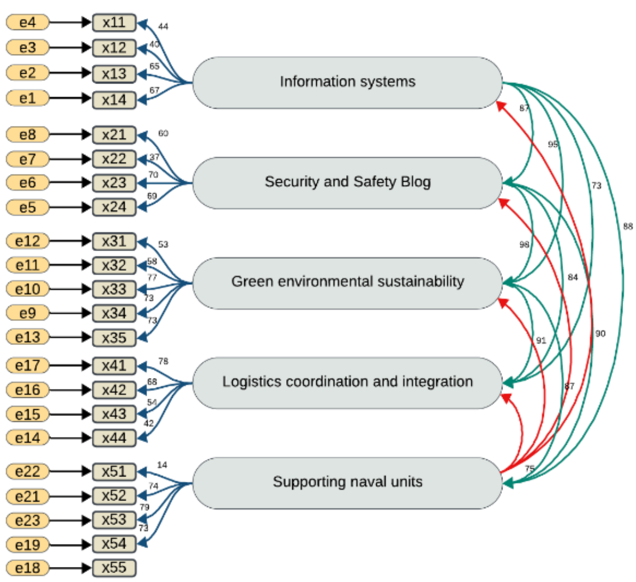

Figure 2. Hypothetical diagram of the confirmatory factor analysis of the dimensions of the independent variable (green maritime logistics)

Moreover, the statistical significance of the factor loadings is indicated by a p-value of less than 0.01 ($p < 0.01$), demonstrating the importance and relevance of the saturation values in the context of the study. These findings underscore that each item is crucial in accurately capturing the corresponding dimension of green maritime logistics activities.

Table 4 below further illustrates the GOF indicators, comparing the hypothetical model and the actual model for the independent variable (green maritime logistics activities). The GOF indicators confirm that the model aligns well with the data, providing robust support for the theoretical structure of green maritime logistics activities.

Table 4. GOF indicators for the applied model of the independent variable (green maritime logistics activities)

Measure	Estimate	Threshold	Interpretation
CMIN	412.367	--	<0.01
DF	99	--	--
CMIN/DF	2.102	Between 1 and 3	Acceptable
CFI	0.985	>0.95	Acceptable
SRMR	0.048	<0.08	Acceptable
RMSEA	0.052	<0.06	Acceptable
PClose	0.057	>0.05	Acceptable

It is clear from Table 4 that the matching criteria are within the permissible limit, which indicates the conformity of the hypothetical model with the actual model of the independent variable (green maritime logistics activities) and its dimensions. Figure 2 shows the hypothetical diagram of the confirmatory factor analysis.

5.3.4 Structural validity, confirmatory factor analysis and Goodness of Fit measures for the dependent variable (operational performance)

The dependent variable, operational performance, was assessed using three key dimensions: energy efficiency, human resources, and infrastructure. Each dimension comprises a set of associated items. To evaluate the theoretical structural model proposed by the researcher, the factor loadings (saturation values) for each item were extracted based on the dimension to which they correspond. Additionally, the GOF criteria were calculated to assess the model's overall fit [24].

Table 5 below presents the factor loadings for the items related to the dimensions of operational performance, illustrating how each item contributes to the measurement of its respective dimension.

Table 5 displays the factor loadings (saturation values) for each item within the operational performance variable. Based on the criteria outlined by Hair Jr et al. [24], a factor loading of greater than 0.40 is required for an item to be retained, as it indicates that the item effectively measures the corresponding dimension. The results show that the saturation values for all items exceed the minimum threshold, meaning that none of the items need to be removed. This confirms that all items within the operational performance dimensions are critical for accurately describing their respective dimensions.

Table 5. Saturation values of the dependent variable paragraphs (operational performance)

Factor	Indicator	Factor Loadings	Std. Error	z-Value	p
	y11	0.702	0.072	7.29	<0.001
Energy efficiency	y12	0.567	0.086	6.482	<0.001
	y13	0.476	0.065	10.994	<0.001
	y14	0.425	0.078	10.954	<0.001
	y21	0.696	0.067	10.843	<0.001
Human resources	y22	0.642	0.091	5.737	<0.001
	y23	0.658	0.062	12.241	<0.001
	y24	0.575	0.057	12.234	<0.001
	y31	0.636	0.075	8.714	<0.001
Port infrastructure	y32	0.633	0.071	10.18	<0.001
	y33	0.56	0.066	12.9	<0.001
	y34	0.439	0.059	14.441	<0.001

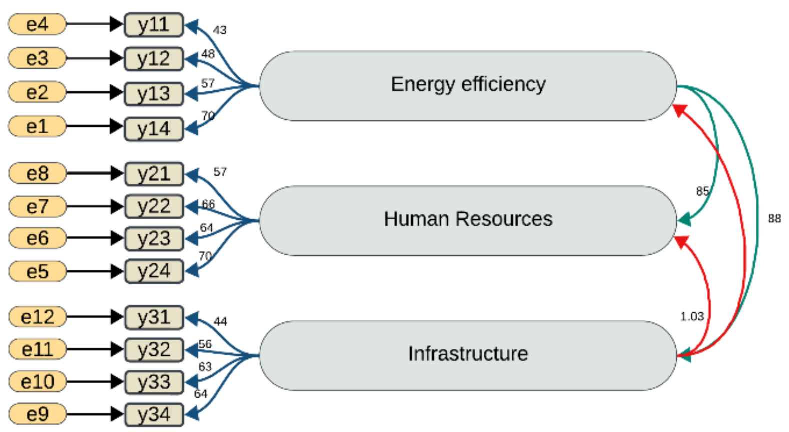

Figure 3. Hypothetical diagram of the confirmatory factor analysis of the dimensions of the dependent variable (operational performance)

Moreover, the results with a significance level of ($p < 0.01$) further emphasize the statistical relevance of the factor loadings, indicating their significance in the model. These findings validate that all items included in the operational performance axis are essential to the assessment of the variable.

Table 6. GOF indicators for the applied model of the dependent variable (operational performance)

Measure	Estimate	Threshold	Interpretation
CMIN	391.332	--	<0.01
DF	83	--	--
CMIN/DF	1.102	Between 1 and 3	Acceptable
CFI	0.964	>0.95	Acceptable
SRMR	0.056	<0.08	Acceptable
RMSEA	0.057	<0.06	Acceptable
PClose	0.068	>0.05	Acceptable

Table 6 above provides the GOF indicators, comparing the fit between the hypothetical and actual models for the dependent variable, operational performance, thereby ensuring the robustness of the model in representing the data.

It is clear from Table 6 that the matching criteria are within the permissible limit, which indicates the conformity of the hypothetical model with the actual model of the independent variable (green maritime logistics activities) and its dimensions. Figure 3 shows the hypothetical diagram of the confirmatory factor analysis.

5.3.5 Analysis and testing of study hypotheses (the analysis and testing of the main hypothesis H and its sub-hypotheses)

The main hypothesis was divided into five sub-hypotheses, each addressing specific aspects of the relationship between the variables. To analyze and test these relationships, both correlation analysis and regression analysis were employed. These methods were utilized to examine the connections and impacts between the independent variables, representing green maritime logistics activities, and the dependent variable, operational performance, as outlined in the main hypothesis (H) and its sub-hypotheses (H_a, H_b, H_c, H_d, H_e) [25].

Table 7 below presents the results of the correlation and regression analyses, which assess the correlation and impact relationships between the independent variables (green maritime logistics activities) and the dependent variable (operational performance).

Table 7. Results of correlation and regression between the independent variables (green maritime logistics activities) and the dependent variable (operational performance)

H	Var.	Beta	t	p	R^2_{adj}	F	p	r	Sig.	Decision
H	Green maritime logistics activities	0.768	12.569	<0.001	0.366	157.974	<0.001	0.605		Accept
H_a	Information systems	0.230	3.112	0.002	0.034	9.686	0.002	0.185	5	Accept
H_b	Security and safety code	0.571	12.337	<0.001	0.357	152.209	<0.001	0.598	2	Accept
H_c	Green environmental sustainability	0.633	12.601	<0.001	0.367	158.797	<0.001	0.606	1	Accept
H_d	Logistics integration coordination	0.544	10.418	<0.001	0.284	108.534	<0.001	0.533	4	Accept
H_e	Supporting maritime units	0.523	9.939	<0.001	0.265	98.782	<0.001	0.515	3	Accept

Table 8. The results of the multiple regression relationship between the independent variables (green maritime logistics activities) and the dependent variable (operational performance)

H	Var.	Beta	t	p	R^2_{adj}	F	p	Decision
H1	Information systems	-0.364	-4.547	<0.001	0.467	47.381	<0.001	Accept
	Security and safety code	0.167	2.196	0.029				
	Green environmental sustainability	0.602	6.110	<0.001				
	Logistics integration coordination	0.064	0.925	0.356				
	Supporting maritime units	0.069	0.917	0.360				

Table 7 presents the results of the correlation and regression analyses for the first main hypothesis (H) and its associated sub-hypotheses. The results indicate the following:

(1) Main hypothesis (H): There is a statistically significant correlation and impact between the independent variable (green maritime logistics activities) and the dependent variable (operational performance). The adjusted coefficient of determination (R_{adj} = 37%) indicates that green maritime logistics activities explain 37% of the variation in operational performance. The F-value of 157.974 ($p < 0.05$) confirms the statistical significance of the model. Furthermore, the correlation coefficient ($r = 0.61$) suggests a strong, direct relationship between green maritime logistics activities and operational performance. As a result, the main hypothesis (H) is accepted.

(2) Sub-hypothesis (H_a): There is a statistically significant relationship between the independent variable (information systems) and the dependent variable (operational performance). The adjusted R-squared value (R_{adj} = 3.4%) indicates that information systems account for 3.4% of the variation in operational performance. The F-value of 9.686 ($p < 0.05$) confirms the significance of the relationship. However, the correlation coefficient ($r = 0.18$) suggests a weak, direct relationship. Despite the weak correlation, the first sub-hypothesis (H_a) is accepted.

(3) Sub-hypothesis (H_b): The results show a statistically significant correlation and impact between the independent variable (Safety and Security Code) and operational performance, with an adjusted R-squared value of 36%. This indicates that Safety and Security Code explains 36% of the variation in operational performance. The F-value of 152.209 ($p < 0.05$) supports the statistical significance of the model, while the correlation coefficient ($r = 0.60$) indicates a strong, direct relationship. Thus, the second sub-hypothesis (H_b) is accepted.

(4) Sub-hypothesis (H_c): A statistically significant relationship exists between the independent variable (green environmental sustainability) and the dependent variable (operational performance), with an adjusted R-squared value of 37%. This means that green environmental sustainability

accounts for 37% of the variation in operational performance. The F-value of 158.797 ($p < 0.05$) and the correlation coefficient ($r = 0.61$) confirm a strong, direct relationship. Accordingly, the third sub-hypothesis (H_c) is accepted.

(5) Sub-hypothesis (H_d): The independent variable (logistics coordination and integration) has a statistically significant impact on operational performance, with an adjusted R-squared value of 29%. This indicates that 29% of the variation in operational performance is explained by logistics coordination and integration. The F-value of 108.535 ($p < 0.05$) signifies the relationship's statistical significance, while the correlation coefficient ($r = 0.54$) indicates a moderate, direct relationship. As a result, the fourth sub-hypothesis (H_d) is accepted.

(6) Sub-hypothesis (H_e): A statistically significant correlation and impact exist between the independent variable (supporting maritime units) and operational performance, with an adjusted R-squared value of 27%. This shows that supporting naval units account for 27% of the variation in operational performance. The F-value of 98.782 ($p < 0.05$) and the correlation coefficient ($r = 0.52$) demonstrate a moderate, direct relationship. Therefore, the fifth sub-hypothesis (H_e) is accepted.

These results provide strong evidence supporting the relationships between the independent variables of green maritime logistics activities and the dependent variable, operational performance, across all dimensions and hypotheses.

Considering the existence of relationships between the independent variables, multiple regression analysis will be used to test and analyze the main hypothesis. In this analysis, there are five independent variables (information systems, security and safety code, green environmental sustainability, logistics coordination and integration, and supporting marine units) and a dependent variable (operational performance).

Table 8 presents the results of the multiple regression analysis and testing of the correlation and impact relationship between the independent variables (green maritime logistics activities) and the dependent variable (operational performance).

The multiple regression analysis for the first main hypothesis demonstrates a statistically significant correlation and impact between the independent variables—information systems, security and safety codes, green environmental sustainability, logistics coordination and integration, and supporting marine units—and the dependent variable, operational performance. The adjusted coefficient of determination ($R_{adj} = 47\%$) indicates that these independent variables collectively explain 47% of the variance in operational performance.

Additionally, the F-value ($F = 47.381$; $p < 0.05$) confirms the overall statistical significance of the model, suggesting that the independent variables exert a meaningful influence on the operational performance of the entities under study. The significance of these findings highlights the critical role that green maritime logistics activities, across various dimensions, play in enhancing operational performance.

In fact, there are several reasons why green maritime logistics has significant and positive impacts on the operational performance of oil ports. These sustainable solutions contribute to improving resource efficiency and reducing harmful emissions, which helps achieve a balance between economic goals and environmental conservation. Also, continuous improvements in the field of green logistics activities contribute to reducing operational costs in the long term, and increase the competitiveness of marine institutions by adhering to environmental safety standards. These practices also lead to improving the flexibility of maritime supply chains and reducing negative impacts on the marine ecosystem.

6. CONCLUSION

The findings of the study revealed a strong correlation between green maritime logistics activities operational performance, particularly in areas like security and safety codes, and green environmental sustainability.

The study mainly indicated that security and safety codes and green environmental sustainability had the strongest positive influence on operational performance, contributing to 36% and 37% of the variance, respectively. While information systems played a smaller role with only a 3.4% contribution, logistics coordination and supporting maritime units demonstrated moderate but statistically significant effects on performance, contributing 29% and 27% of the variance, respectively. Based on these results, the paper concluded that incorporating green practices contributes to reducing pollution in Iraqi oil ports. In the same context, the paper comes up with the idea that integrating green maritime practices, particularly those focused on safety and sustainability, can substantially enhance operational performance. The results underscore the Contribution of sustainable logistics practices in the maritime sector to achieve both environmental and operational improvements, offering valuable insights for future strategies in the oil and maritime industries. Also, green maritime logistics boosts operational performance and fostering awareness.

Therefore, the authors call to adopt green practices in Iraqi oil ports, given their role in achieving environmental sustainability and keeping pace with the global shift towards renewable energy and moving away from fossil fuels with environmentally friendly activities. Having said that, the authors suggest conducting a comparative study between green logistics practices and traditional non-green logistics practices in different areas rather than oil ports as future work that could highlight the benefits more starkly. As far as the results of my study are concerned with similar studies, the results showed that providing green logistics capabilities and potentials, such as the use of renewable energy and improving fuel efficiency, contribute significantly to reducing operational costs and environmental impact, while improving the efficiency of operations in ports. Compared to similar studies in other countries, such as the Netherlands and the United States, which showed improved operational performance in their oil ports through the adoption of green technologies, the results in Iraq differ due to the challenges of infrastructure and limited resources.

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