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THE RELATIONSHIP BETWEEN SENSOR TECHNOLOGY AND PERFORMANCE OF SHIPPING LINES IN KENYA: THE MODERATING EFFECT OF INTERNATIONAL MARITIME REGULATIONS

Njeri M. Nancy[1*], Musau Enock[1],

Nyaoga B. Richard[2] and Ngacho Christopher[1]

[1]School of Business and Economics, Kisii University P.O. Box 408 – 40200, Kisii, Kenya
[2]Faculty of Commerce, Egerton University P.O. Box 13357 – 20100, Nakuru, Kenya
*Corresponding author's email address: muthoninjeri582@gmail.com

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ABSTRACT: *Over time, firms have adopted various measures to enable them to improve their performance; one such measure is the adoption of technology. Shipping lines' performance, just like any other organisation's performance, is highly pegged on proper implementation and use of the right technology. The need for technology adoption arises from the fact that Kenya's shipping sector has been characterised by low logistics efficiency due to high transportation costs, delayed delivery, clearance at the port, the influx of substandard goods into the country as well as poor tracking and tracing. If well utilised, the sensor technology can help solve these problems. The objective of this study, therefore, was to assess the relationship between sensor technology and the performance of shipping lines in Kenya and the moderating effect of international maritime regulations. The main theory of the study was the technology acceptance model supported by the task technology fit theory, institutional theory and theory of the firm. The positivist research philosophy and explanatory survey research design were utilised in this study. The target population was all the 2835 respondents who are logistics, IT, sales and marketing and finance staff of the 53 shipping lines listed in Kenya business directory 2021. The study sample size was 438 respondents who were staff from four departments and was determined by the use of the Yamane formula. A random stratified sampling design was utilised to arrive at specific respondents. Quantitative data were collected using structured questionnaires administered to the respondents. A pilot study was conducted in Mombasa from six shipping lines using 10% of the sample size; 50 questionnaires, but only 44 were filled and returned. The questionnaire was tested for both validity and reliability. Reliability was tested using Cronbach's alpha index at 0.7, while the use of factor analysis ascertained validity. Quantitative data was appropriately coded and entered into SPSS version 20 for analysis to generate descriptive statistics (minimum, maximum, mean, standard deviation kurtosis and Skewness) and inferential statistics (Pearson correlation coefficient, multiple linear regression and hierarchical regression model), which was then be presented in frequency tables and graphs. Results showed that there was a significant and positive relationship between sensor technology and the performance of shipping lines in Kenya. Also, international maritime regulations had a statistically significant moderating effect on the relationship between sensor technology and the performance of shipping lines in Kenya. It was concluded that shipping lines in Kenya utilised localisation technology to help in locating cargo during transportation, forecasting lead time accurately, mapping the route, eliminating delay, checking route deviation and tracking vessels. The study recommends that in order to enhance the shipping line's performance through efficient operations, the managers of these companies need to adopt and make use of the sensor technology.*

KEYWORDS: Sensor Technology, Shipping Lines Companies, Reliability, Validity, Factor Analysis, Performance, International Maritime Regulations.

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INTRODUCTION

According to UNCTAD's (2020) review of maritime transport, maritime transport (shipping) contributes 90% of international trade volume. This industry forms a key component of maritime logistics, and it contributes significantly towards a country's economy, given that it aids international trade by enabling the transportation of goods from one country to the other by water transport (Notteboom and Rodrigue, 2017).

Blue economy, which Shipping is part of, advocates for the use of water resources for the economic development of a country. Kenya, for instance, in 2018 hosted a global conference on sustainable blue economy and one of the resolutions passed was to identify appropriate technologies that can accelerate the sustainable development of the blue economy (Data collection survey on blue economy in the republic of Kenya, 2018). Due to the fast volumes of trade involved in shipping lines, it is necessary to devise mechanisms to improve their performance. One way that shipping lines can improve their performance is through the use of supply chain management technologies. Harris, Wang and Wang (2015) argue that integrating technology into a firm's operations can lead to better performance. de Barros *et al.* (2015) also opine that the vast application of technology is due to the resulting benefits of improving performance.

Shipping lines' performance, just like any other organisational performance, is a multi-dimensional construct measured through different indicators, but the sole purpose of this is to evaluate whether the organisational goals have been achieved. Researchers use different performance measures based on the context. For instance, Aramyan et al. (2007) suggest that performance can be viewed from efficiency, responsiveness, flexibility and quality dimensions. On the other hand, Toyli et al. (2008) argue that shipping lines' performance is multi-dimensional, involving logistics cost, operational metrics and service level. Fugate *et al.* (2010) allude to shipping lines' performance being viewed from three dimensions: efficiency, effectiveness and differentiation.

A firm's performance relates to how well an organisation achieves its goals and objectives. Key performance indicators of shipping lines' are cost, delivery time, customer service, market share, profitability and customer satisfaction (Ndonye, 2014; Macharia, Iravo, Tirimba & Ombui, 2015). Globally, Karia & Wong (2013) argue that if well implemented and used, technology can lead to better performance of logistics firms in terms of cost reduction. However, there is a need to conduct further research to determine how various logistics resources can be combined and used to improve logistics firms' performance. Proper implementation and use of this model positively impacted shipping companies' security, business resilience and customer performance (Sadovaya & Thai, 2015).

At the global level, a number of studies have been conducted linking the use of technology and the performance of shipping lines. Bode & Weiss (2011) opine that the use of technology can help to prevent loss and risk in the transportation chain by being able to inform about the status of goods during transportation. Implementing and using the right technology enable a firm to achieve better performance in terms of lead time reduction, sales growth and return on investment (Lui 2015). Cost reduction, safety and security, and customer satisfaction were some of the benefits gained by firms that use technology; this is according to Musa, Azmi, Shibghatullah, Asmala and Abas (2017).

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At the international level, several researches have been conducted linking the usage of supply chain management technologies and the performance of shipping lines. Assuming, Kofi and Chelbi (2011) contend that the use of RFID technology has enabled the company to achieve tracking of counterfeit drugs and reduced the cost of tracking by 6-7%. The research links improved logistical performance to adoption and use of the right technology. The study focuses only on RFID technology, whereas other supply chain management technologies can be used in combination with this to yield better results.

The use of auto-identification technologies helps improve a firm's performance in terms of cost reduction (Urban & Darlington, 2011). The research finding links improved organisational performance to the use of the right technology. However, they concentrate on a single type of technology and not a combination of them to carry out this role.

There is a significant correlation between maritime logistics performance and competitiveness of international trade, as opined by Onyemejor (2015). The information links technology to performance and argues that there is a positive correlation between the use of the right technology and the performance of maritime logistics firms.

At the regional level, several kinds of research have been conducted linking the use of sensor technology and the performance of shipping lines. This technology usage has led to cost and time reduction in the movement of goods physically (Moh'd 2016).

Different types of systems, such as inventory management, fleet management, logistics integration and information flow that use sensor technology, have a positive impact on the performance of logistics firms, this is according to Kyomo (2019). At a local level, several studies have been carried out linking the use of supply chain management technologies

Ndonye (2014) contends that there is a strong relationship between a firm's performance in terms of efficiency and effectiveness and the use of information technology and that logistics firms dealing with cargo transportation. He also opines that there is a positive relationship between the use of technology and organisational performance.

Proper use of technology by logistics firms enhances cost and time reduction, quality and competitiveness in their operations Gacuru & Kabare (2015). There is a significant positive relationship between technology and the performance of logistics firms Macharia, Iravo, Tirimba & Ombui (2015).

Mugambi (2017) argue that the Electronic cargo tracking system adopted by Kenya Revenue Authority has had a positive impact in terms of avoiding cargo diversion into the local market, reduction of cargo monitoring cost as well as reducing the time taken to clear the cargo at the border There is a significant positive relationship between use of e-customs and service delivery, e-customs revenue systems and service delivery of e-customs risk analysis system and service delivery; e-customs monitoring systems and service delivery (Sakhasia, 2017).

Nyongesa (2018) opines that RECTS positively impacted transit goods through the reduction of transit time, reduction of dumping goods in the country as well as providing a timely response. Kabui, Gakobo and Mwaura (2019) argue that a single window system has a positive influence on customs goods declaration procedures, shipping procedures and pre-clearance permits.

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THEORETICAL AND EMPIRICAL REVIEW

Technology Acceptance Model

The technology acceptance model was the main model used in the study, and it was supported by the task technology fit theory for the independent variable, institutional theory for the moderating variable and firm theory for the dependent variable. The relevance of the theory to this study was to justify the reasons behind the use of sensor technology for the performance of shipping lines.

Institutional Theory

Shipping being inherently an international affair, is regulated by the international maritime organisation. This organisation is mandated with the responsibility of drafting rules and regulations to be adhered to by shipping lines (UNCTAD 2020). Each member state has a body that ensures that IMO regulations are adhered to. In Kenya, the Kenya maritime authority (KMA) is the body responsible for overseeing IMO regulations and country boundaries (IMO Review 2020). The mandatory adherence to International maritime regulations will be anchored on Institutional theory, which attends to aspects of social structure. It considers the processes by which structures, including schemas, rules, norms and routines, become established as authoritative guidelines for social behaviour (Scott, 2004). Institutional theorists assert that the institutional environment can strongly influence the development of formal structures in an organisation, often more profoundly than market pressures. Innovative structures that improve technical efficiency in early-adopting organisations are legitimised in the environment.

An institutional theory which explains the rules and regulations pertaining to the logistics firms industry and the mandatory requirements of their day-to-day operations will be used to support the reason why logistics firms adopt sensor technology. They do so in a bid to adhere to the set rules and regulations by the government and to avoid penalties and loss of customers.

Firm theory

The theory of the firm was founded by Ronald Coase in 1937. The theory comprises three economic theories that seek to explain why a firm exists and the impact of market price on its performance. The theory argues that firms will seek to reduce costs and maximise profit. Given that Logistics companies in Kenya are privately owned, profit maximisation will be one of their key objectives. This theory will be used to support the dependent variable, which is the performance of logistics firms.

The theory of the firm provides the reasons as to why a firm exists, given the fact that almost all logistics firms are private entities, profit maximisation and cost reduction will be key among their objectives. This will necessitate the logistics firms to adopt these supply chain management technologies for them to reap the resulting benefits of using these technologies.

Empirical literature review

Sensor technologies include wireless sensor networks, Nanosensors and the Internet of Things. These technologies can be used to monitor a wide range of environmental conditions such as temperature, humidity, as well as shocks and gases in transport containers and vessels and then

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record such information at specified intervals (Skorna *et al.*, 2011). Diallo & Sene (2012) argue that the data collected by sensors must represent the current environment status so that if the goods being transported are at any risk, collective measures can be taken. The sensor technology can also help to avoid cargo tampering, notify cargo diversion, detect faults in goods, enhance transportation of environmentally sensitive goods and detect counterfeit goods. Sensor technologies are very important in logistics performance, as evidenced in the following studies.

Skorna, Bode & Weiss (2011) conducted a study that sought to investigate how risk and loss can be prevented in logistics using sensor technology. The variables of the study were sensor technology and its impact on the transport chain. The study was carried out in the US and was guided by two objectives: one was to find out the number of claims made due to loss and risk made by transport companies in a specified period. Two was to develop a framework that can be used by transport companies using sensors technologies to avert risk and loss. The study made use of the purposive literature review method, and the sample size was made up of 7284 claims that had been made in that particular period. The collected data was analysed through variance analysis, and found that the use of sensor technologies can help prevent loss and risk in the supply chain by informing about the status of goods during transportation. This is because these technologies permit the automatic measurement of many environmental conditions, such as temperature, humidity, acceleration, chemical composition and pressure. The conclusion of the study was that these technologies help to know the condition of goods while in transit and that corrective measures are taken at the right time, which is important for logistics firms to deliver goods to their customers in the right condition. The research study recommends the implementation of risk management that is technology enabled for the firms to reduce the risk and loss experienced during cargo transportation. The study was conducted in a developed country which may represent the case in developing countries and focus on a wider logistics scope. In contrast, the current study has been narrowed to maritime logistics and specifically the shipping lines.

Studies in this area have been furthered by Himanka (2016) conducted a study that sought to investigate Internet of Things devices' uses in logistics. The variables of the study were the Internet of Things and its benefits in logistics. The study was carried out in Finland, and the objective was to analyse the uses of Internet of Things devices in logistics. The study employed a case study method, the unit of analysis being DHL. The findings were that Internet of Things devices, such as wireless sensor networks, are useful in monitoring light, humidity, shock and temperature for the cargo during transit. This information is then shared with the relevant parties in the logistics process. The study concluded that IOT devices are beneficial to the logistics service providers. The study recommends that logistics service providers develop Internet of Things device standards.

In a similar study, Hiekata, Wanaka, Mitsuyuki & Ueno (2020) conducted a study that analysed the use of the Internet of Things (sensor technology) in the maritime industry. The study variables were sensor technology and its impacts on the maritime industry. The study was carried out in Japan. The objective of the study was to reinforce the use of Internet of Things technology in maritime logistics. The research employed a case study method. The variables of the study were the Internet of Things and the maritime industry. The simulation method was used to evaluate the relationship between the two variables. The findings of the study were that use of the Internet of Things had a positive impact on maritime industry performance, such as

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profitability and control of ship damage. The research differs from this one in methodology and locality.

Shaikh, Kamble & Siddharath (2021) study examined the development of sensor technology in the shipping industry. The variables of the study were sensor technology and operational performance in shipping. The study was conducted in Mumbai, and the objective was to analyse the effect of sensor development in the shipping industry as well as the challenges experienced in an effort to adopt this technology. The study employed an extensive literature review method. The findings of the study were that; one adoption of this technology will help the maritime industry to compete with other industries. Two, the use of sensor technology will positively affect shipping efficiency and safety. The study differs from this one in terms of methodology

According to Kuma (2015) conducted a study to analyse the use of vessel traffic management systems in the maritime industry as a security tool. The study variables were traffic management and its effect on the maritime industry. The study was carried out in Ghana, and its objective was to the impact of these systems in enhancing maritime security. The study employed a qualitative research method to collect primary data from various agents from Ghana maritime stakeholders. Secondary data was also gathered from Ghana's maritime authority and international maritime authority. The study findings were that there is a significant relationship between the use of these systems and improved maritime security. The study focuses on only one type of technology instead of focusing on four main types of supply chain management technologies. The study is also different in terms of methodology.

Agrifoglio, Cannavale, Laurenza & Metallo (2017) investigated the impact of digital technology on maritime operational management. The variables of the study were technology and its impact on maritime operations. The objective of the study was to analyse the effect of digital technology on operations management in the maritime industry. The study variables were digital technologies and maritime operations management. The study employed a case study method, and data was collected through the use of a questionnaire. The findings of the study were that use of digital technology had a positive effect on maritime operation management. The study differs from this one in terms of methodology and its focus on the umbrella of digital technology instead of specific supply chain management technologies.

Similarly, Khan & Adediji's (2017) study sought to investigate maritime traffic management by use of a radar system in Congo. The study variables were radar systems and their impact on maritime traffic management. The study's objective was to analyse the impact of Radar systems on maritime traffic management. The primary research data was collected from the maritime personnel department using questionnaires. Secondary data was also used from respective departments. Analysis of variance technique was used to analyse the data. The study's findings were that use of these technological systems eliminated human error that led to mishaps and had a significant positive effect on the management of maritime traffic. The study differs from the current one due to secondary data usage and indicates the Radar system as the only enabler for managing maritime traffic.

In line with the previous studies, Mugambi (2017) investigated how cross-border trade between Kenya and Uganda is affected by cargo tracking systems. The study variables were electronic cargo tracking systems and their impact on the shipping industry across the border. The objectives of the research were to evaluate the use of ECTS at the border and two to determine

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the effect of these systems on cross-border trade. The study was anchored on institutional theory and transaction cost theory. The study made use of an exploratory research design method and focused on the enquiry structure in order to draw inferences from the relationships. The sample size of the study was 30 respondents, made up of headquarters and border officials. The collected data were analysed using both descriptive and inferential statistics. The study found that the electronic cargo tracking system adopted by Kenya Revenue Authority has had a positive impact in terms of avoiding cargo diversion into the local market, reduction of cargo monitoring costs as well as reducing the time taken to clear the cargo at the border. The conclusion of the study was that the cross-border trade between Kenya and Uganda is positively affected by the use of electronic cargo tracking systems. The findings may not be applicable to logistics processes. The study differs from the current study regarding some theories and research methodology.

Sakhasia (2017) conducted a study that sought to investigate electronic customs management's effect on service delivery. The variables of the study were electronic systems and their effects on service delivery. The study was carried out in Eldoret, Kenya and was guided by the following objectives; one was to assess the effect of the electronic customs clearance system on service delivery at KRA Eldoret station. Two was to determine the impact of the effect of electronic customs revenue system on service delivery at KRA Eldoret station. Three was to analyse the effect of the electronic customs risk analysis system on service delivery at KRA Eldoret station. Four was to assess the effect of the electronic customs monitoring system on service delivery at KRA Eldoret station. The study was anchored on the capability approach theory. The study employed a descriptive research design, and data were collected using a questionnaire and interview schedule. The sample size of the study was 200 respondents, which comprised 198 customs agents and exporters and 2 KRA customs employees. The collected data was analysed using descriptive, inferential statistics and document analysis. The findings of the study were that; one, there is a significant positive relationship of $p > 0.01$ between the use of e-customs and service delivery. Two, there is a significant positive relationship of $p > 0.01$ between the use of e-customs revenue systems and service delivery. Three, there is a significant positive relationship of $p > 0.01$ between the use of the e-customs risk analysis system and service delivery. Four, there is a significant positive relationship of $p > 0.01$ between the use of e-customs monitoring systems and service delivery. The study concluded that e-customs have ban positive influence on service delivery at KRA. The study recommends KRA update its software regularly and educate its employees, and trade on the essence of ethics as well as accountability.

Further studies have been conducted in this area Nyongesa (2018) sought to find out how transit goods are impacted by RECTS. The study variables were cargo tracking systems and their effects on shipping operational performance. The study was done in Kenya. The research objectives were to evaluate the influence of: one transit time reduction on transit goods management, two seamless monitoring of goods being transited, three stakeholders' transparency on transit goods management, and four accountability on transit goods management in KRA. It was anchored on the technology acceptance model and employed a descriptive research design. A sample size of 60 respondents was used in the study, and it comprised various stakeholders of transit goods management and the Kenya revenue authority. The collected research data was analysed using SPSS, and results were presented in tables and graphs. The findings of the study were that RECTS positively impacted transit goods through the reduction of transit time, reduction of dumping goods in the country as well as providing a

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timely response. The study concludes that RECTs has managed to reduce the cost of transit goods management, but it has not eliminated the dumping of goods at border points. The recommendations of the study were that more seals should be purchased in order to meet the needs of revenue authorities and that more investment should be made in humans so as to reconcile the transit goods management. The study fails to give other factors that enable RECTS to give firms operational efficiency. The study is different from the current study in terms of some theories and research methodology.

CONCEPTUAL FRAMEWORK

The independent variable was sensor technologies, and the dependent variable was shipping lines' performance being moderated by International maritime regulations. International maritime regulations such as SOLAS, ISM, MARPOL, COLREG, LOADLINES and ISPS have for a long time been for a long time observed by shipping lines to adhere to the International Maritime Organisation (IMO) conventions. International maritime regulations in this study were used as a moderator in the relationship between sensor technology and the performance of shipping lines.

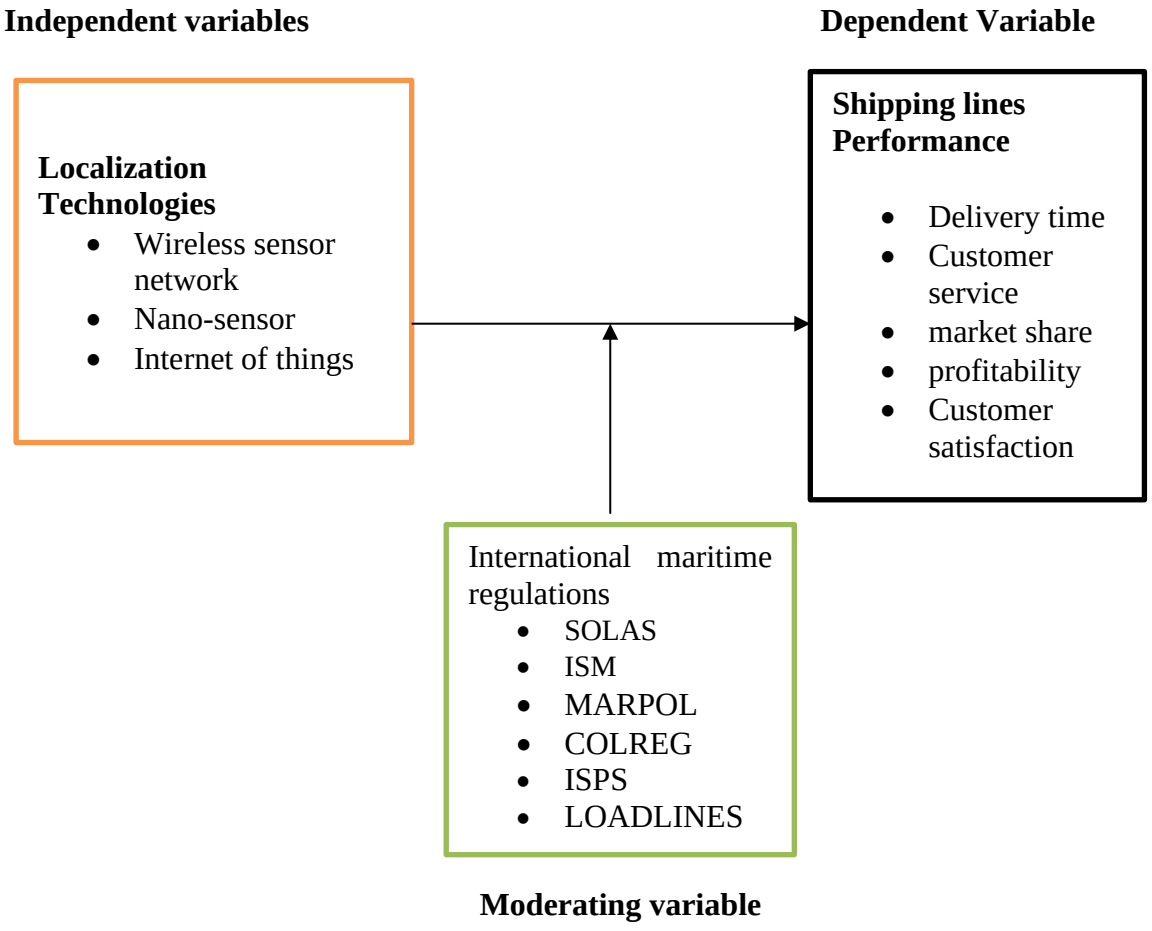

Fig 1 Conceptual framework

Source: *Researcher (2021)*

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METHODOLOGY

A research philosophy is a researcher's perception of the world and how it gives rise to assumptions that underpin one's research process (Antwi & Hamza, 2015). They further assert that research philosophies are broadly categorised into positivism, Interpretivism, realism or pragmatism.

Positivism research philosophy underpinned this study and held that the goal of knowledge was simply to describe the phenomenon that people experience (William, 2006 and Robert, 2008). The positivist paradigm mostly involves quantitative methodology. It also involves the administration of pre-and post-tests to measure gain scores. Here, the researcher is external to the research site and is the controller of the research process (Taylor and Milton, 2013).

In the positivist view, science is the way of getting the truth, understanding the world well and hence controlling it. According to Eric (1998), positivists study the parts to understand the whole. The positivists look for regularities and casual relationships to enable them to understand and predict the social world.

Research design

According to Roller and Lavrakas (2015), a research design forms the basis or framework of research. Maxwell (2013) defines research design as the roadmap that directs data gathering, collecting and analysing and is a map of the manner in which a study is carried out as per the data needed so as to assess the research questions in an orderly manner. According to Creswell (2014), explanatory research design can be used to predict an outcome such as the performance of shipping lines. Consequently, an explanatory research design w used to investigate the influence of supply chain management technologies on the performance of shipping lines in Kenya by estimating the relationships between various aspects of supply chain management technologies and the performance of shipping lines. Given the objectives and as illustrated in chapter two under the conceptual framework, the study used an explanatory research design. According to Kothari (2004), explanatory research design facilitates research to be as efficient as possible, yielding maximum information.

The explanatory research design was used to investigate the influence of sensor technology on the performance of shipping lines in Kenya by estimating the relationships between various aspects of sensor technology and the performance of shipping lines. According to Kothari (2004), explanatory research design facilitates research to be as efficient as possible, yielding maximum information.

Sample size

For the purpose of obtaining a sample that was considered optimum and needed to make generalisations about the whole population (Table 3.1: staff from shipping lines targeted for this study), the size of the sample will be determined using the Yamane (1976) formula. The sample size will be calculated as follows:

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n= N÷ (1+Ne^2)

Where n=number of samples

N=total population

e= error tolerance

n=2835 ÷1+ (2835*0.05^2) = 350

n=350

In similar studies, response rates have ranged between 68% to 80%. (Atieno, 2014 -68.3%; Abbas, 2016 - 78%: Kilonzi & Kanai, 2020 - 75%). The study will provide for non-response in line with Sivo et al. (2006), who argue that in social sciences that gather data through a self-administered questionnaire, the response rate is normally 80%. In this study, therefore, the expected nonresponse rate will be 20% hence the final sample size will be 350/ 0.8 = 437.5

=438

The sample size of 438 respondents was selected using stratified and simple random sampling from the four departments' employees, which were grouped into four strata. IT department, Finance department, Logistics department and sales and marketing department of these shipping lines that form the target population were used to gather the research data. This sampling technique ensures equal chances of every item in the population being selected in the target population (Mugenda & Mugenda, 2013).

Table 1: Sample size

Department	**No. of staff**	**n.Xi/N**	**sample size**
Logistics	706	706 ÷ 2835 × 438	109
Finance	666	666 ÷ 2835 × 438	103
Information technology	623	623 ÷ 2835 × 438	96
Sales and marketing	840	840 ÷ 2835 × 438	130
Total	**2835**		**438**

Source: Kenya Business List Directory 2021

Sensor Technology

Table 2: Kaiser-Meyer-Olkin and Bartlett's Test for Sensor Technology

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.510
Bartlett's Test of Sphericity	Approx. Chi-Square	86.796
	Df	15
	Sig.	.000

Source: ***Field Data 2022***

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Bartlett's test of Sphericity is used to test the validity of the instruments. A score of .000 was recorded, showing that the variable was suitable for factor analysis. A score of less than 0.05 indicated a rejection of the null hypothesis since the correlation matrix was an identity matrix. This, therefore, showed that the variables were suitable for factor analysis. On the adequacy of the sample size using the Kaiser-Meyer- Olkin (KMO) test, a score of 0.710 was recorded. This indicated that there was sample adequacy for factor analysis. The results of the factor analysis are presented in Table 3.

Table 3: factor loadings for Sensor technology

Rotated Component Matrix[a]				
	Component			
	1	2	3	Comment
The WSN is highly utilised by your company as a sensor technology in its operations		.912		Retained
WSNs are adequate sensor technology for monitoring environmental conditions that are risky to goods during transportation		.926		Retained
There is high utilisation of Nanosensors by your organisation in its operations			.824	Retained
Nanosensors are adequate technology for avoiding cargo tampering during transportation			.892	Retained
IoT as a sensor technology is utilised by your firm in its operation	.916			Retained
IoT is adequate technology for detecting faults in goods	.933			Retained

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
a. Rotation converged in 4 iterations.

Source: Field Data 2022

The study findings showed that all six items had a factor loading above 0.5; therefore, all 6 items were retained. According to Chakraborty (2010), items with a factor loading of 0.5 or more should be retained, while those with a factor loading lower than 0.5 should be dropped.

Model Specification 1

To examine the relationship between Sensor technology and the performance of shipping lines in Kenya

$Y = \beta_o + \beta_1 X_1 + \varepsilon$……………………………………………………………………(1)

Where Υ= performance of shipping lines

X_1= Sensor technology is the independent variable

B_o= Constant (Y intercepts)

β_1= coefficient of the regression

ε= error term

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Model Specification 2

In the second step, the moderating factor was introduced to equation 1 above to have

$Y = \beta_o + \beta_1 X_1 M + e$……(2)

Where;

Y = Firm's performance

β_o = Constant (Y intercepts)

β_{1-4} =Regression coefficient

X_1 = Independent variables (Sensor)

M = International maritime regulations

e = margin of error

RESULTS AND DISCUSSIONS

Performance of shipping lines

Shipping line performance entails the measurement of the extent to which a firm achieves its goals and objectives. The sampled responses in relation to the Performance of shipping lines have been assessed and presented in Table 4.

Table 4 Descriptive statistics for Shipping lines performance

Statement	N	Min.	Max.	Mean	Std. Dev	Skewness	Kurtosis
The utilisation of technology has led to reduced delivery time for the firm	360	1	5	4.05	.750	-.803	.922
The use of supply chain management technologies has made your Firm increase its market share	360	1	5	4.29	.625	-.513	.402
The use of supply chain management technologies has made your Firm increase its market share	360	1	5	4.31	.707	-.675	-.213
The profitability of the firm has increased since your firm started using these technologies	360	2	5	4.27	.679	-.720	.660
Customer satisfaction has been improved with the use of these technologies by your firm	360	3	5	4.45	.571	-.424	-.760
Overall score	**360**			**4.274**	**0.6664**	**-0.627**	**0.2004**

Source: *field Data 2022*

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The findings indicated that the overall score for shipping lines' performance was a mean of 4.274. The variation of responses was low, with a standard deviation of 0.6664, whereby the individual statements recorded a standard deviation of around 1.000. The highest variation of 0.750 was recorded for the statement 'The utilisation of technology has led to the reduced delivery time of the firm,' which had a mean of 4.05. The lowest variation of 0.571 was recorded for the statement ' Customer satisfaction has been improved with the use of these technologies by your firm,' which had a mean of 4.45 this means the research respondents agreed with the statement on improving shipping lines' performance through the use of supply chain management technologies. This resonates with the study carried out by Karibo (2019), who argued that the use of supply chain management technologies had a significant positive effect of 0.982 and 0.964 on shipping performance in terms of timely delivery and increased sales, respectively.

In the statement 'The use of supply chain management technologies has made your Firm increase market share,' the research respondents agreed at a mean of 4.31 and a variation at a standard deviation of 0.707 that shipping lines performance has improved in terms of increased market share. This is in agreement with the studies that were conducted by Ndonye (2014), Macharia, Iravo, Tirimba & Ombui (2015) and Maina (2017), who contended that there is a positive relationship between the use of technology and shipping lines performance in terms of cost reduction, time reduction, quality service and competitiveness in their operations.

In the statement 'Customers service of the firm has improved with the use of supply chain management technologies,' the respondents agreed with a mean of 4.29 and a variation showing a standard deviation of 0.625. This is in line with the study by Ojwang, who posited that use of technology improved shipping line efficiency by reducing lead time, providing quality services and providing timely feedback.

On the statement, 'The profitability of the firm has increased since your firm started using these technologies,' the respondents agreed at a mean of 4.27 and a variation showing a standard deviation of 0.679. This is in agreement with the study carried out by Njagi, Namusonge, & Mugambi (2016), who posited that there is a positive relationship between the use of technology and the performance of shipping firms in terms of profitability.

Sensor technology encompasses wireless sensor networks, Nanosensors and the Internet of Things. These technologies can be used to monitor a wide range of environmental conditions such as temperature, humidity, as well as shocks and gases in transport containers and vessels and record such information (Skorna et al., 2011 and Diallo & Sene, 2012). The researcher sought to find out the application of this technology in the organisation and their effectiveness in cargo tampering, notifying cargo diversion, detecting faults in goods and contributing to shipping line performance. The sampled responses in relation to sensor technology have been assessed and presented in Table 5.

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Table 5 Descriptive Statistics for Sensor Technology

Statement	N	Min	Max	Mean	Std. Dev	Skewness	Kurtosis
The WSN is highly utilised by your company as a sensor technology in its operations	360	1	5	3.55	1.025	-1.002	.531
WSNs are adequate sensor technology for monitoring environmental conditions that are risky to goods during transportation	360	1	5	3.70	.765	1.304	2.473
There is high utilisation of Nanosensors by your organisation in its operations	360	1	5	3.87	.835	-.103	-.758
Nanosensors are adequate technology for avoiding cargo tampering during transportation	360	1	5	3.82	.962	-.540	.033
IoT as a sensor technology is utilised by your firm in its operation	360	1	5	4.15	.857	-1.333	2.364
IoT is adequate technology for detecting faults in goods	360	1	5	4.31	.760	-1.132	1.482
Overall score	**360**			**3.9**	**0.8673**	**-0.9023**	**1.0208**

Source: *field Data 2022*

Table 5 indicated that the overall score for sensor technology was a mean of 3.9. The variation of responses was low, with a standard deviation of 0.8673, whereby the individual statements recorded a standard deviation of around 1.000. The highest variation of 1.025 was recorded for the statement 'The WSN are highly utilized by your company as a sensor technology in its operations,' which had a mean of 3.55. The lowest variation of 0.760 was recorded for the statement ' IOT is adequate technology for detecting a fault in goods,' which had a mean of 4.31 this means the research respondents agreed with the statement on sensor technology as one of the supply chain management technologies that aid in improving shipping lines performance. This is in agreement with the study carried out by Shaik, Kamble & Siddharath (2021), who posit that use of sensor technology positively affected shipping efficiency and safety.

In the statement that 'WSN is adequate sensor technology for monitoring environmental conditions that are risky to goods during transportation', the respondents agreed with a mean of 3.70 and a variation showing a standard deviation of 0.765. This is in line with the studies by Agrifoglio, Cannavale, Laurenza & Metallo (2017) and Hiekata, Wanaka, Mitsuyuki & Ueno (2020), who contended that the use of this technology has a positive impact on maritime industry performance such as profitability.

On the statement 'There is high utilisation of Nanosensors by your organisation in its operations,' the respondents agreed at a mean of 3.87 and a variation showing a standard deviation of 0.835. On the other hand, in the statement 'Nanosensors are adequate technology for avoiding cargo tampering during transportation,' respondents agreed at a mean of 3.87 and

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a standard deviation of 0.962 that the sensor technology is effective in avoiding cargo tampering during transhipment. This is in line with the study by Skorna, bode & Weiss (2011), who found that using this technology enables the shipping lines to detect cargo tampering in the cause of transportation, improving their performance.

In the statement on 'IOT as a sensor technology is utilised by your firm in its operations,' the research respondents agreed at a mean of 4.15 and a variation at a standard deviation of 0.857 that their firms utilise the Internet of things as sensor technology. This is in agreement with the study carried out by Himanka (2016), Kuma (2016) & Mugambi (2017), who contended that the use of this technology has a positive impact on shipping line performance by improving security and reducing inspection time.

International Maritime Regulations

International maritime regulations are presented by conventions such as SOLAS, ISM, MARPOL, COLREG, LOADLINES and ISPS, each serving a distinct purpose. These regulations are meant to guard the lives of seafarers, marine pollution, and cargo weight limit. The international maritime regulations have an impact on the relationship between supply chain management technologies and the performance of shipping lines. The researcher sought to find out the moderating effect of these international maritime regulations on the relationship between supply chain management technologies and shipping line performance. The sampled responses in relation to international maritime regulations have been assessed and presented in Table 6.

Table 6 Descriptive Statistics for International Maritime Regulations

Statement	N	Min	Max	Mean	Std. Dev	Skewness	Kurtosis
Your organisation strictly observes the SOLAS convention during its operations	360	1	5	4.15	.938	-1.380	1.743
ISM adherence affects your operations and consequently affects your performance	360	1	5	4.23	.705	-.987	2.227
Observing the MARPOL convention has an effect on your firm's operation	360	1	5	4.29	.837	-1.697	4.024
Your organisation strictly observes the COLGEG convention	360	1	5	4.38	.812	-1.805	4.478
Your organisation adheres to the LOADLINES convention during its operations	360	1	5	4.34	.815	-1.310	1.737
Your organisation strictly observes ISPS conventions during its operations, and this affects its performance	360	1	5	4.40	.753	-1.810	5.101
Overall score	**360**			**4.298**	**0.810**	**-1.4981**	**3.2183**

Source: *field Data 2022*

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Table 6 shows that the overall score for international maritime regulations was a mean of 4.2983. The variation of responses was low, with a standard deviation of 0.810, whereby the individual statements recorded a standard deviation of around 1.000. The highest variation of 0.938 was recorded for the statement 'Your organisation strictly observes SOLAS convention during its operations,' which had a mean of 4.15. The lowest variation of 0.705 was recorded for the statement ' ISM adherence affects your operations and consequently affects performance,' which had a mean of 4.23 this means the research respondents agreed to the statement on international maritime regulations affects shipping lines performance gained after using supply chain management technologies. This agrees with the studies carried out by Kombo (2018) and Oraith (2020), who posited that international maritime regulation significantly moderates the relationship between the two.

In the statement 'Observing MARPOL convention has an effect on your firm's operations,' the research respondents agreed at a mean of 4.29 and a variation at a standard deviation of 0.837 that observing the MARPOL convention has an effect on your firm. In the statement, 'your organization strictly adheres to LOADLINES convention,' the respondents agreed with a mean of 4.34 and a variation showing a standard deviation of 0.815. This is in agreement with the study carried out by Oraith (2020), who posited that international maritime regulation has a significant moderating effect on the relationship between the two On the statement 'your organisation strictly observes ISPS convention during its operations, and this affects its performance,' the respondents agreed at a mean of 4.40 and a variation showing a standard deviation of 0.753. On the statement 'your organisation strictly observes COLREG convention during its operations,' the respondents agreed at a mean of 4.38 and a variation showing a standard deviation of 0.812. This agrees with the study carried out by Kombo (2018), who posited that international maritime regulation has a significant moderating effect on the relationship between the two.

Correlation Analysis

The research used the Pearson product-moment correlation coefficient to test the strength of the relationship between the variables. The Pearson product-moment correlation coefficient was used to determine the strength of a linear relationship between the independent variable (supply chain management technologies) and the dependent Variable (Shipping lines performance). The Pearson correlation coefficient assumes values between +1 and -1; where +1 indicates a strong positive correlation, -1 indicates a strong negative correlation, and a value of 0 means there was no relationship between the independent and dependent variables. Values closer to 0 indicated a weak relationship, either positive or negative. The results of the correlation analysis of the research are presented in Table 7.

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Table 7 Correlation Analysis

		ST	SL P	
ST	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	360		
SLP	Pearson Correlation	.321**	.	1
	Sig. (2-tailed)	.000		
	N	360		360

Source: *field Data 2022*

The research also showed that there was a positive correlation between Sensor technology and shipping line performance, with a correlation coefficient of 0.321 at a 5% level of significance. The p-value of the relationship was .000, which indicated that the correlation was significant since the obtained p-value of .000 conformed to a p-value <0.05. These results showed that a significant change in shipping lines' performance was explained by sensor technology use. This is in line with the study of Sakhasia (2017), which contended that the use of sensor technology led to the performance of shipping lines.

Sensor Technology and shipping lines performance

The research study sought to assess the relationship between Sensor Technology and the performance of shipping lines in Kenya. To achieve the objective, the following hypothesis was tested: **Ho**$_{2,}$ there is no statistically significant relationship between Sensor technology and the performance of shipping lines in Kenya. The model formulated was $Y = \beta_o + \beta_2 X_2 + \varepsilon$, where Y if the performance of shipping lines, βo is a constant, β_2 coefficient of regression, X_2 is the Sensor technology is the independent variable, and ε is the error term. To achieve objective two and test the hypothesis, the researcher carried out a regression analysis of the variables whereby the R and R^2 were obtained the results are shown in Table 4.23.

Model Summary on Sensor Technology and Shipping lines performance

The model summary in Table 8 shows the values of R, R2 and the adjusted R2, as well as the standard error of the estimates, which were used to determine how well a regression model fitted the data. The model summary showed the extent of variation in the outcome variable to the predicator variables in the model. The results are presented in Table 8.

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Table 8: Model summary for Sensor Technology and Shipping Lines performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change
1	.333[a]	.111	.108	.31245	.111

a. Predictors: (Constant), Composite Effect of ST
b.Dependent Variable: Shipping lines' performance
Source: field Data 2022

The results shown in Table 8 above showed that the value of R^2 was 0.111 or 11.1 % which implied that 11. 1% of the variations in shipping line performance were explained by sensor technology, whereas 88.9% of the variations in performance were explained by other factors.

ANOVA on Sensor Technology and Shipping lines performance

The Analysis of Variance (ANOVA) was used to check the model's fitness in predicting the relationship between the dependent and independent variable, In this case, the relationship between sensor technology and shipping lines' performance. The results of the analysis are presented in Table 9.

Table 9: ANOVA on Sensor Technology and Shipping Lines performance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.346	1	4.346	44.517	.000[b]
	Residual	34.949	358	.098		
	Total	39.295	359			

a. Dependent Variable: Shipping lines' performance
b. Predictors: (Constant), Composite Effect of ST
Source: field Data 2022

Table 9 shows the computed values and the p-value. The calculated value of F (1, 358) = 44.517 and a p-value of 0.000. Using the p-value to check the model's fitness showed that the model was fit to explain the relationship between the predicator variable Sensor Technology and the dependent variable shipping lines performance since the p-value obtained 0.000 is less than 0.05. Further, this is confirmed by the use of the F values. The calculated value of F at (1,358), where 1 was the numerator and 358 was the denominator, showed that the calculated F value was 44.517, while the critical F value at a 5% significance level was 3.8676.

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The results are in agreement with those that were reported by Himanka (2016) and Shaikh, Kamble & Siddharath (2021), who found that use of a significant positive relationship between the use of sensor technology and the performance of shipping lines.

Coefficient on Sensor Technology and Shipping lines performance

From the results and discussion, the researcher conducted a regression coefficient to establish the mean change in shipping line performance for a unit variation in Sensor technology among the shipping lines in Kenya. The regression coefficients were thus established to show the mean change in the dependent variable due to the change in the independent variable. The model allowed the prediction of a dependent variable given an independent variable. The findings are presented in Table 10.

Table 10: Regression coefficients on Sensor Technology and shipping lines performance

Model		Unstandardised Coefficients		Standardised Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.630	.141		18.682	.000
	C	.239	.036	.333	6.672	.000

a.Dependent Variable: Shipping lines' performance

Source: field Data 2022

Table 10 showed the constant coefficient, that is, the point where the regression line touched the y-axis in the graph was positive since most of the shipping lines had reported positive returns after the use of Sensor technology based on the findings. The slope of the line was also positive, showing a change in performance with the continued proper use of sensor technology. Table 4.25 indicates that the constant coefficient β_o is 2.630 while the standardized β_1 is .239 this shows the unit change in Sensor technology brought about a change in performance of .239.

To test the hypothesis using a t-test, the t-value obtained of 18.682 at a 95% level of significance was higher than the critical t- value of 1.6496 for the sample size used in this study. This, therefore, led to the rejection of the null hypothesis **Ho**$_{2.}$

Based on the above results, the study derived the following simple linear regression equation for sensor technology on shipping lines performance.

$Y = 2.63o + .239X_2 + \varepsilon$

The second objective of the research study was to examine the relationship between sensor technology and the performance of shipping lines in Kenya. From the findings, it was established that there was a significant positive relationship between sensor technology and the performance of shipping lines in Kenya. Based on the results, the null hypothesis **Ho**$_{2,}$ There is no statistically significant relationship between sensor technology and the performance of shipping lines in Kenya, was rejected since the calculated t-value 18.682 is greater than 1.645.

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The study findings concur with Kuma (2015) and Agrifoglio, Cannavale, Laurenza & Metallo (2017), who showed that the use of sensor technology has an effect on shipping line performance. The findings further agreed with Sakhasia (2017), Mugambi (2017) and Nyongesa (2018), who showed that there is a significant and positive relationship between localisation technology and shipping lines performance.

International Maritime Regulations, Sensor Technology and Performance of Shipping Lines

Objective 5b of the research study were to assess the Moderating effect of International maritime regulations on the relationship between sensor technology and the performance of shipping lines in Kenya.

Model Summary of International Maritime Regulations, Sensor Technology and Performance of shipping lines

The model summary in Table 11 showed the values of R, R2 and the adjusted R2 as well as the standard error of the estimates, which were used to determine how well a regression model, fitted the data. The model summary showed the extent of variation in the outcome variable to the predicator variables in the model. The results are presented in Table 11.

Table 11: Model summary of International maritime regulations, Sensor technology and performance of shipping lines

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change
1	.333[a]	.111	.108	.31245	.111
2	.342[b]	.117	.112	.31182	.006

a. Predictors: (Constant), IMR, the composite effect of ST
b. Dependent Variable: Shipping Lines' performance
Source: *field data 2022*

The results shown in Table 11 above showed that the R^2 for the relationship between sensor technology and shipping lines performance was 0.111 0r 11.1 % before the moderator's introduction. After the introduction of the moderator (international maritime regulations) in the relationship, the R^2 increased to 0.117 or 11.7 %, this showed that international maritime regulations accounted for 0.006 or 0.6% of the increase in shipping lines performance.

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ANOVA on International Maritime Regulations, Sensor Technology and Performance of Shipping Lines

The Analysis of Variance (ANOVA) were used to check the fitness of the model in predicting the link between the moderator, the dependent and independent variables, In this case, the link between International maritime regulations, Sensor technology and shipping lines performance. The results of the analysis are presented in Table 12.

Table 12: ANOVA on International maritime regulations, Sensor technology and performance of shipping lines

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	4.346	1	4.346	44.517	.000[b]
	Residual	34.949	358	.098		
	Total	39.295	359			
2	Regression	4.584	2	2.292	23.572	.000[c]
	Residual	34.711	357	.097		
	Total	39.295	359			

a. Dependent Variable: Shipping lines' performance

b. Predictors: (Constant), IMR, composite effect of ST

Source: *Field data 2022*

Table 12 showed the computed values and the p-value for models 1 and 2.The calculated value for model 1(before the introduction of the moderator) for F (1, 358) = 44.715 and a p-value of 0.000. While the calculated value for model 2(after the introduction of the moderator) for F (2,357) = 23.572. Using the p-value to check the fitness of the model in assessing the moderating effect showed that the model was fit since the p-value obtained of 0.000 is less than 0.05. The same results were found when using the F-value to test the fitness of the model. The calculated value of F (2,357), where 2 was the numerator and 357 was the denominator, showed that the calculated F-value = 23.572 was higher than the critical F-value = 3.02101 at a 5% significance level.

Coefficients of International Maritime Regulations, Sensor Technology and Performance of Shipping Lines

From the results and discussion, the study conducted a regression coefficient to establish the mean change in shipping line performance for a unit variation in international maritime regulations among the shipping lines in Kenya. The regression coefficients were thus developed to show the moderating effect of international maritime regulation on the relationship between a dependent variable and the independent variable. The model allowed the prediction of the moderating effect of international maritime regulations on the relationship between Sensor technology and shipping lines' performance. The results are shown in table 13

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Table 13: Coefficients of International maritime regulations, Sensor technology and performance of shipping lines

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.630	.141		18.682	.000
	ST	.239	.036	.333	6.672	.000
2	(Constant)	2.512	.160		15.733	.000
	ST	.211	.040	.293	5.249	.000
	IMR	.053	.034	.087	1.564	.119

a. Dependent Variable: Shipping lines Performance

Source: *Field data 2022*

Table 13 showed the coefficients in a straight line equation on the moderating effect of international maritime regulations on the relationship between sensor technology and shipping lines performance. These were the coefficients that were used to predict the moderating effect of international maritime regulations on the relationship between Sensor technology and shipping line performance. The constant βo as shown in Table 13, was positive, implying that the regression line started on a positive point on the Y-axis. This was because most shipping lines have an improvement in performance due to the use of this technology. The slope of the line was also positive, implying that international maritime regulations have a positive moderating effect on the relationship between sensor technology and shipping line performance. Table 13 showed the unstandardised constant coefficient β_0 2.630 while unstandardised coefficient $\beta_2 = .211$ while $\beta_6 = 0.053$

To test the **H_o 5b** hypothesis using the t-test, the calculated t-value 5.249 at a 95% level of significance was found to be higher than the critical t-value of 1.6496. Hence the null hypothesis **H_o 5b,** international maritime regulations have no statistically significant moderating effect on the relationship between Sensor technology and performance of shipping lines in Kenya, was rejected because 5.249 is greater than 1.6496.

Based on the above results, the study derived the following linear regression equation for the moderating effect of international maritime regulations have no statistically significant moderating effect on the relationship between Sensor technology and the performance of shipping lines.

$Y = 2.630 + .211X_2 + 0.053M + \varepsilon$

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CONCLUSION AND RECOMMENDATIONS

The study's main objective was to examine the relationship between supply chain management technologies and the performance of shipping lines in Kenya. The specific objectives of the study were to examine the relationship between localisation technology, to assess the relationship between sensor technology, to examine the relationship between communication technology, to assess the relationship between localisation technology and the performance of shipping lines in Kenya as well as examine the moderating effect of international maritime regulations between independent and dependent variables.

Relationship between Sensor Technology and Performance of Shipping Lines in Kenya

The second objective of the study was to assess the relationship between sensor Technology and performance of shipping lines in Kenya. The research findings showed that the respondents agreed that shipping lines make of sensor technology such as Wireless sensor networks, Nanosensors and the Internet of Things (IoT) in their operations. The respondents were of the view that the Sensor technology being used in their firms is adequate in monitoring a wide range of environmental conditions, avoiding cargo tampering, notifying cargo diversion, detecting faults in goods and enhancing transportation of environmentally sensitive goods. The respondents also agreed on the ability of the shipping lines to use sensor technology contributed to their improved performance.

Correlation analysis indicated that there was a significant positive relationship between Sensor technology and the performance of shipping lines. Regression analysis also showed that Sensor technology and the performance of shipping lines have a significant positive relationship of R^2 0.111. These results indicated that Sensor technology adequately explains the performance of shipping lines in Kenya. The second hypothesis of the study (H_o2), that there is no statistical relationship between Sensor technology and the performance of shipping lines in Kenya, was hence rejected, and the conclusion reached is that there is a significant positive relationship between Sensor technology and the performance of shipping lines in Kenya.

Sensor technology has been found to have a positive relationship with the performance of shipping lines. Similar results were obtained by Hiekata *et al.* (2020), who analysed the use of sensor technology (Internet of Things) in the maritime industry in Japan. The findings of the study were that the use of IOT positively impacted the maritime industry such as performance. Additionally, Shaikh, Kamble & Siddharath's (2021) study examined the development of sensor technology in the shipping industry in Mumbai. The findings of the study were that there is a positive relationship between the adoption and use of this technology and improved shipping performance in terms of efficiency and safety.

It was concluded that there was a significant and positive relationship between sensor technology and the performance of shipping lines in Kenya. It was also concluded that shipping lines in Kenya utilised sensor technology to help them in monitoring a wide range of environmental conditions, avoid cargo tampering, notify cargo diversion, detect faults in goods and enhance transportation of environmentally sensitive goods. The study findings corroborated with the findings of Himanka (2016), Khan & Adediji (2017) and Hiekata *et al.* (2018), which further reinforced the conclusion that the use of sensor technology by shipping lines (logistic firms) improved their performance. The results of the study showed that the use of this technology had a positive effect on performance. This showed that the use of Sensor

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technology positively affects shipping line performance. This showed that the use of sensor technology enables the detection of faulty goods, and monitoring environmental conditions for environmentally sensitive good areas will improve shipping lines' performance.

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