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Harnessing cutting edge technologies in combating procurement fraud

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Abstract - As deep-sea mining and marine mineral extraction enterprises expand into underexplored oceanic territories, the intricacy of these operations introduces multifaceted challenges. These include elevated operational costs, technical sophistication, increased susceptibility to fraudulent activities, workforce capacity gaps, as well as ethical and regulatory concerns. This study explores the role of cutting-edge technologies in mitigating procurement fraud within the marine mineral sector in North Central Nigeria. Specifically, it examines the impact of artificial intelligence adoption on enhancing the detection and prevention of procurement-related fraud. This research utilized a quantitative research method using a survey technique as an instrument for data collection. The study utilized the Tarro Yamane method to determine sample size. The study adopts a quantitative research method. The questionnaire was administered to a population of four hundred and eight (480) participants with in the North central, Niger State and Plateau State. Bowley proportional allocation method was used to determine an optimum number of questionnaires suitable for each stratum within the selected states, North Central, Niger State and Plateau State, Nigeria. The Pearson correlation result revealed that artificial intelligence positively influences procurement fraud detection in the deep-water mining Industry. This result confirms a positive result with the value of (p .000, r = .990, N = 207). Managers are advised to deploy digital technologies to monitor and track marine mineral production, supply chain activities, and financial transactions of firms. This will help firms to enhance transparency, trust, decrease human errors, and improve data quality. This study advances trust-disruptive theory by connecting emerging technology and procurement using deep-seawater or marine mineral sectors. The study provides deep-water mining industry and other organizations with new insight on how to proactively assess and manage procurement problems leading to the cost of adopting new technology and staff development, and compliance demands

Keywords: Emerging Technologies, Procurement Fraud, Artificial Intelligence, Marine Mineral Sector

1. Introduction

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There is growing interest in deep-sea mining, particularly in the North Central Region, Nigeria. The use of smart systems aids in the automation of deep-sea mineral mining activities. Al serves as a technological bridge that supports both operational optimization, risk mitigation in deep-sea mining, and fraud detection in the procurement system (Benevides, Costa, & Silva, 2023; Organization for Economic Development, OECD, 2020; Nature Communications, 2023). In large-scale projects involving deep-sea mining, procurement is critical for contracts for ships, equipment, and environmental monitoring services. AL identifies irregularities in the procurement systems. Intelligent systems can automate the detection of fraudulent activities. Procurement platforms enhanced with artificial intelligence can monitor transactions for inconsistencies in deep-sea or marine mining extractions, ensuring financial integrity and legal compliance.

The adoption of digital technologies has emerged as a strategic response to enhance transparency, efficiency, and accountability in deep-sea mineral extraction. The paradigm shift in digital technology enables the marine mining industry to shift from manual, reactive methods to automated, predictive mechanisms to improve operational performance. Additionally, the use of AI in the deep-sea mining sector supports the Blue Ocean strategy, where mineral extraction can be explored at a low cost, reduced risk, and at the same time more economically. This also allows for early detection, with AI systems being able to identify anomalies in data, such as strange shipment patterns or unusual activity around contracts, which prevents financial losses and damage to reputation (Adeniran & Akintoye, 2023).

Benevides et al. (2023) have identified the potential of technological tools to enhance the operational efficiency of firms. The author posits that digital tools such as remote sensing, digital twin simulations, blockchain, and cloud-based data analytics are increasingly employed to monitor marine extraction processes and detect irregularities in real-time. By leveraging advanced digital technologies such as artificial intelligence, firms can transition from reactive compliance frameworks to proactive, intelligence-driven governance models. This shift enables organizations to anticipate risks, ensure regulatory alignment, and embed ethical oversight into their operational strategies.

According to the United Nations Conference on Trade and Development (UNCTAD, 2024), digital technologies streamline operations and enhance compliance with international standards, thereby enhancing a company's environmental and social license to operate. By embracing such innovations, firms are positioning themselves in blue oceans where differentiation and regulatory alignment become key drivers of sustainable competitive advantage. Additionally, Adeniran and Akintoye (2023) also opined that the use of AI for marine mining supports the Blue Ocean strategy in executing differentiation and low cost at the same time. This also allows for early detection, with AI systems being able to identify anomalies in data, such as strange shipment patterns or unusual activity around contracts, which prevents financial losses and damage to reputation.

Related to this, Masocha and Fatoki, (2022) also concur that both digital technology and blue ocean strategies allow firms to capture new value by minimizing risk while pioneering ethical, tech-driven governance structures. Thus, technology adoption becomes not just a defensive measure but a forward-looking strategy for leadership in a high-stakes industry. The adoption of technology refers to the use of new technology to improve the efficiency and effectiveness of work processes (Ugwu et al., 2021). The authors state that the firm that adopts advanced technology enhances their operational efficiency and productivity. Benevides et al. (2023) and Masocha and Fatoki (2022) identified that artificial intelligence is leveraged to monitor mineral extraction, logistics, and financial transactions in real time, minimizing opportunities for illicit behavior. These systems serve to safeguard accounts and are essential in educating themselves with international regulatory frameworks, thus further improving investor and stakeholder confidence. In mineral extraction industries.

Previous studies have examined the influence of leveraging technology across industries and countries. According to a study by West (2021), machine learning and artificial intelligence

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have improved the effectiveness of fraud detection algorithms. Nearly 97% of fraud examiners concur that analytics tools greatly increase the efficiency and accuracy of fraud detection, according to the Association of Certified Fraud Examiners (ACFE, 2024). Additionally, AI-driven fraud detection systems can automate the discovery of suspicious patterns, minimizing human error and the risk of ignoring fraudulent acts.

Ezeji (2024) investigated how artificial intelligence might be used to identify and stop procurement fraud in South Africa using a mixed techniques approach. The result showed that fraudsters are becoming increasingly skilled, which makes it difficult to identify fraudulent activity. Barajei et al. (2023) assessed how e-procurement may reduce procurement fraud and corruption in Ghanaian mining enterprises. The study revealed the breaking of the monopoly of power, transparency and accountability, and breaking of information asymmetry, as e-procurement anti-corruption variables that combat procurement fraud and corruption in the mining companies. Acheampong (2024) examined the role of emerging technologies in improving procurement efficiency and effectiveness in Ghana using secondary data. The adoption of technologies such as blockchain, artificial intelligence (AI), Internet of Things (IoT), and big data analytics has streamlined procurement processes, enhanced transparency, and fostered better decision-making.

Considering the above, there is limited research on digital technologies to enhance fraud detection in marine mining in North Central Nigeria. Research on this area is significant in applying the blue ocean perspective to navigate the low-cost market using the marine industry.

As deep-sea mining and marine mineral extraction enterprises expand into underexplored oceanic territories, the intricacy of these operations introduces multifaceted challenges. These include elevated operational costs, technical sophistication, increased susceptibility to fraudulent activities, workforce capacity gaps, as well as ethical and regulatory concerns. As a result, many firms prefer to continue using outdated and inefficient systems, leading to data inconsistencies and errors. Limited investment in centralized or cloud-based solutions creates data silos, making it difficult for stakeholders to access and analyze information efficiently. An outdated and inefficient system can lead to data inconsistencies, errors, operational inefficiencies, and financial losses in the mining industry.

In addition, deploying AI-based fraud detection in the deep-sea mining sector requires significant investment in technology, infrastructure, and skilled personnel, which may be difficult for some firms to afford. Without continuous updates, these systems can lose effectiveness over time. Cybercriminals and insiders may exploit AI vulnerabilities, manipulating algorithms or evading detection. Therefore, risks related to bias in artificial intelligence models, cybersecurity, cost, lack of transparency, and weak institutions can increase the potential for fraud in the marine mining industry. Algorithms may reflect historical biases, leading to false positives or missed fraud. The general objective of this study is to investigate the influence of digital technology adoption on procurement fraud detection in the deep-water mining industry in North Central, Nigeria. The specific objective of the study is to examine the influence of artificial intelligence adoption on procurement fraud detection in the deep-water mining industry.

Technology adoption is the process by which businesses incorporate cutting-edge technologies like artificial intelligence (AI), robotics, and cloud computing into their operations (Acemoglu, Gary, David, Catherine, Eric, Emin, Lucia, Nathan, John, Zachary, Pascual & Nikolas, 2023). Both external market conditions and firm-specific factors, such as size, industry, and employment trends, influence this adoption. The adoption process also highlights inequalities across organizations depending on resources and innovation preparedness by reflecting variations in the rate and scope of technology integration. According to the authors, the adoption of technology involves embedding advanced technologies into business processes, which enhances efficiency and innovation.

Advanced technologies like AI and machine learning enable businesses to innovate more quickly, leading to the development of new products and services that meet evolving market demands. This allows companies to remain competitive by anticipating market shifts and technological trends (Acemoglu et al., 2023). Leveraging data analytics tools, firms gain actionable

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insights into customer behavior, operational inefficiencies, and market opportunities. This allows organizations to make informed strategic decisions, enhancing competitiveness (McAfee & Brynjolfsson, 2012). AI tools are used for predictive analytics, automating repetitive tasks, and tailoring customer experiences. Companies using AI gain advantages through personalization and operational efficiency (Davenport & Ronanki, 2018).

According to Scott (2024), artificial intelligence refers to the use of computer systems to carry out tasks that ordinarily need human intelligence. The author posits that some of these tasks that a computer system performs include learning, reasoning, problem-solving, perception, and language comprehension. Xie and Li (2020) also identified other tasks that artificial intelligence (AI) performs in detecting fraudulent activity in the procurement sector. The authors posit that AL is used to examine enormous volumes of transaction data and identify any fraudulent practices or suspicious trends that might point to fraud. The use of Algorithms is used to identify anomalies that are typical indicators of procurement fraud, such as duplicate invoices, overbilling, or the establishment of fake vendors.

Collins (2021) concurs that Artificial Intelligence (AI), specifically machine learning (ML), is being used to increase procurement processes' transparency and automate the detection of fraudulent activity. The author explains further that leveraging the AL solution helps procurement teams monitor transactions to spot anomalies that can lead to fraud. AI automates the process of matching invoices to goods receipts and purchase orders (POs), greatly lowering the possibility of overcharging or invoice inconsistencies. This approach reduces fraudulent payments and increases efficiency by ensuring that payments are only made for goods or services that were genuinely received.

Transparency International (TI, 2022) also defined procurement fraud refers to any misconduct or deception that occurs in the acquisition of goods or services, where unethical practices like favoritism or corruption interfere with fair competition and value for money." Transparency International highlights that procurement fraud leads to the misallocation of public funds and corrupt practices, such as bribery, favoritism, and kickbacks. These actions prevent the effective use of taxpayer money, often resulting in inflated project costs or substandard goods and services.

A recent study by Neil (2023) found that 56% of US businesses experienced vendor fraud, and the majority of those who fell victim to fraud attempts were singled out more than once. According to the study, 5% of US companies were targeted more than 15 times, and 12% of all US companies were targeted more than 10 times. The paper claims that these unprecedented figures might be attributed to the evolving sophistication and organization of fraudsters.

Trust Disruptive Theory serves as a foundation for this study and was postulated by Christensen and Bower in 1995. The central idea of the theory is that companies that fail to incorporate technological resilience into their procurement procedures are more likely to be vulnerable to fraud (Christensen, 1997; Christensen & Bower, 1995). Additionally, fraudulent activities result when people or organizations take advantage of the system where there is a lack of supervision, accountability, or openness. In other words, fraud takes advantage of trust gaps between procurement parties, and technology can stop fraud by filling these gaps. When procurement officers, suppliers, and other stakeholders lose faith in one another, it can result in chances for dishonest practices, including bribery, kickbacks, or fraudulent invoicing (Christensen, 1997; Christensen & Bower, 1995).

According to Tapscott and Tapscott (2016), technology, especially cutting-edge solutions like artificial intelligence, blockchain, smart contracts, and sophisticated monitoring systems, can close this trust gap by guaranteeing accountability, openness, and traceability in every procurement transaction. All transactions are safely recorded and accessible to authorized parties thanks to blockchain, a decentralized and unchangeable ledger. The authors posit that every transaction about the acquisition of products or services can be monitored from the point of origin to the point of delivery. Because it creates a transparent audit trail that all parties involved can confirm, this transparency lowers the possibility of fraud and corruption. The distributed nature of blockchain guarantees that no one party has authority, which promotes trust among all parties.

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The Trust Disruption Theory is relevant to this study objective with a focus on leveraging cutting-edge technology in combating procurement fraud in a marine mining firm in North Central Nigeria. This study advances the theory by highlighting the role of technological advancements in bridging trust gaps, particularly in procurement processes. By introducing systems that ensure transparency, data integrity, and accountability, technology plays a central role in preventing fraud and restoring trust among all stakeholders. The synergy between trust and technology is vital for reducing fraudulent activities and improving the resilience of procurement systems.

Several academics have researched technology adoption and procurement fraud both in Nigeria and across the globe. These studies have produced mixed results. Some of these studies on this subject are stated below.

Angeline, Hui, Cheng-Hsien and Maria Cecilia (2025) evaluated the adoption of digital technologies in the maritime industry, Singapore. This study uses a mixed-methods approach that comprises in-depth interviews with three interviewees and a preliminary survey with 30 respondents. The analyses revealed that the maritime industry recognizes digitalization as essential in addressing key challenges, including costs, cybersecurity, adaption to new technology, and sustainability, among others.

Andrzej (2023) examined the role of artificial intelligence (AI) methods in detecting bid rigging in public procurement, particularly within infrastructure projects. Key findings highlight that bid rigging, a form of procurement fraud involving collusion among bidders, leads to inflated contract prices and reduced competitiveness. The study emphasizes how AI techniques, such as machine learning (ML), can analyze historical bidding data to detect irregularities and patterns indicative of collusion. This research underscores the importance of integrating advanced analytics into procurement systems to uphold fairness and efficiency in infrastructure projects.

The study by Gadour (2024) investigated whether e-procurement and artificial intelligence (AI) can effectively reduce corruption in public procurement processes in Africa. The study employed secondary data to achieve its aim. The research revealed the importance of integrating technology with structural reforms to combat corruption and enhance procurement efficiency across Africa.

Andrzej and Wojciech (2018) examined techniques for spotting bid rigging and collusion in the construction sector, emphasizing the identification of trends that point to anti-competitive behavior. Certain trends were found to be possible indicators of cartel behavior, including consistent bid prices, stable market shares, and coordinated price hikes. The results demonstrated how crucial it is to integrate economic theory with sophisticated data analysis to successfully identify and stop bid rigging, particularly in public infrastructure projects.

Naek (2024) investigated the optimization of artificial intelligence to address injustice in bankruptcy requirements between state-owned enterprises and private companies in Indonesia. The research applied a normative juridical method where secondary data is utilized to achieve study objectives. The research findings indicate that the injustice in bankruptcy requirements is primarily caused by the differing legal treatment and policies that favor State-Owned Enterprises. The utilization of AI in bankruptcy data analysis and decision-making can assist in identifying patterns of injustice and provide more equitable and transparent recommendations.

Indra-Praja (2024) identified the role of artificial intelligence in reducing and preventing discrimination against BPJS patients in Health Services in Indonesia. The research applied a normative juridical method where secondary data is utilized to achieve study objectives. The results showed that AI has significant potential in detecting and preventing discrimination, for example through algorithms that monitor the treatment of patients in real-time.

Noviantini, and Arifin-Hoesein (2024) explored the application of artificial intelligence in Enhancing Legal Protection for Patients in Dental Practice: A Positivist Perspective in Indonesia. The research applied a normative juridical method where secondary data is utilized to achieve study objectives. The research findings showed that the application of AI in dentistry enhances legal protection for patients by improving diagnostic accuracy and reducing medical errors.

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Barajei et al. (2023) assessed how e-procurement may reduce procurement fraud and corruption in Ghanaian mining enterprises. The study used a self-administered questionnaire as an instrument for data collection. Factor analysis was then used to analyze the data. The study found that e-procurement anti-corruption factors that fight procurement fraud and corruption in mining businesses include the dismantling of the monopoly of power, openness, accountability, and the dismantling of information asymmetry.

Ugwu and Balogun (2024) evaluated the influence of the adoption of technological advancement on supply chain management in Selected Nigerian Brewery Plc, South-East Zone Nigeria. A survey was carried out to a total population of 2,100 staff of the organization. Using Taro Yamane's method, a sample size was determined as 336. A proportionate allocation formula was applied in the distribution of the survey in the following states: River State, Bayelsa, Akwa Ibom, Delta, and Edo State, Nigeria. Out of 336 copies of a questionnaire sent to the participants, only 321 were returned and utilized for the study, while the remaining 15 copies were not utilized for this study. The study hypotheses were statistically tested and analyzed using Pearson correlation methods at a 5% significance level. The findings indicate that artificial intelligence (AI) adoption positively contributes to supply chain visibility (SCV) when the p-value (.000) is less than a 5 % level of significance ($p < 0.05$).

2. Method

The study adopts a quantitative research method. The questionnaire was administered to a population of four hundred and eight (480) participants with in the North central, Niger State and Plateau State. Bowley proportional allocation method was used to determine an optimum number of questionnaires suitable for each stratum within the selected states, North Central, Niger State and Plateau State, Nigeria.

Bowley's allocation formula is stated below as follows:

$$nh = \frac{nNh}{N}$$

Where nh = Bowley's allocation formula
Nh = Number of items in each stratum in the population.
N = Sample size
N = Population size

Applying the formula, we have:

i). Plateau, State - Office $nh = \frac{220 * 218}{480} = 99.92 = 100$

ii). Niger State – Office $nh = \frac{260 * 218}{480} = 118.08 = 118$

Additionally, the instruments were given to experts for review and to provide feedback on their content and structure. Each instrument consisted of both positive and negative statements related to digital technology adoption and Procurement fraud. The choice of analytic tools was carefully selected to match the study-specific objectives and the type of data collected. Using a preliminary sample of fewer questionnaires, the researchers conducted preliminary pilot testing to test the reliability of the instrument. Primary data were analyzed using Pearson correlation techniques to determine the relationship between dependent and independent variables.

3. Results and Discussion

3.1 Results

Primary data were collected, tabulated, and analyzed using the Statistical Package for Social Science (SPSS Version 25). Out of 218 copies of the questionnaire distributed to the respondents, only 118 were filled out and returned, while the remaining were not returned and used for the analysis. The demographic information of the age respondents is presented below.

Table 1: Age Bracket of the Respondents

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Age Bracket	Frequency	Percentage
25 – 35	35	10
35 – 45	32	11
45 – 55	14	40
55 – 65	10	30

Source: (Field Survey, 2024)

Table 1 presents respondents in various age brackets. The pie chart visualizes that those aged 45-55 years make up the largest segment (40%) of the population, indicating a significant proportion of middle-aged individuals in the sample. Again, the result of the age between 55 – 65 years represents 30%, this group is also prominent, showing a strong presence of older adults. Again, 35 – 45 years, constituting 11% of the population, indicating that this younger middle-aged group is less represented. Finally, 25 – 35 years of the workforce represent the youngest age bracket accounts for only 10% of the staff, indicating minimal participation or presence of young people. The demographic information of the age of the respondent is stated below.

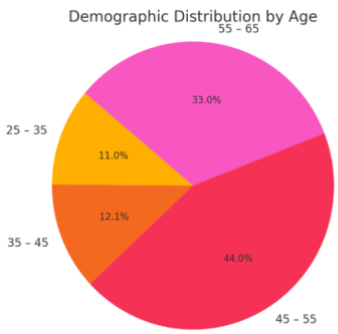

Table 2: Highest Educational Qualification of Respondents

Highest Educational Qualification	Frequency	Percentage
SSSC or Lower	22	20
B.sc/B.Eng	139	45
M.sc	17	20
Ph.D.	3	15
Total	220	100

Source: (Field Survey, 2024)

Table 2 presents respondents with the highest educational qualifications. The pie chart visualizes that B.Sc/B.Eng holders make up the largest group (45%), indicating that nearly half of the respondents possess an undergraduate degree in science or engineering. Furthermore, SSSC or lower and M.Sc holders each account for 20% of the population, reflecting a balanced representation between respondents with basic and postgraduate education. Ph.D. holders make up the smallest segment (15%), suggesting limited representation of respondents with doctoral-level education. The demographic educational qualification of the respondents is stated below.

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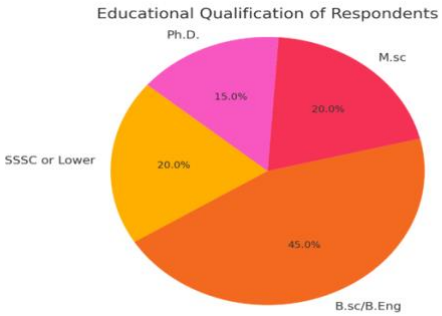

3.1.1 Analysis of Research Question

How does artificial intelligence enhance procurement fraud in the deep-sea mining industry, North Central, Nigeria?

Table 3: Investigative Questions on Artificial Intelligence and Procurement Fraud

S/N	Questions	SA	AG	UN	DA	SD	Total
A.	**Artificial Intelligence (Independent Variable)**						
1	My organization can handle large-scale operations using AI-empowered systems, making them suitable for global organizations with high transaction volumes.	50	53	5	4	6	118
2	Automating fraud detection in my organization helps reduce the need for manual reviews, cutting operational costs for businesses.	51	52	1	6	8	118
3	In my firm, we deploy AI to enable seamless fraud detection across various platforms, including online, mobile, and in-store transactions.	52	54	3	2	7	118
4	Most times, my firm forecasts potential fraud risks with the aid of AI using historical data and allowing preemptive measures to be taken.	55	56	4	3	0	118
5	AI performance depends on the quality and quantity of training data, which may not always be optimal.	53	55	2	7	1	118
6	Sometimes, implementing AI-driven fraud detection systems requires significant investment in technology and expertise.	51	59	2	1	5	118
7	Understanding and managing AI systems requires specialized knowledge, which might be a barrier for some organizations.	53	54	8	1	2	118
B.	**Bid Rigging (Dependent Variable)**						
1	Fraud detection systems help my firm ensure fair competition by identifying collusion and irregularities in the bidding process.	50	57	5	3	3	118

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2	Effective detection mechanisms reduce financial losses caused by inflated bids, benefiting organizations and taxpayers.	51	54	5	2	6	118
3	Sometimes, over-reliance on automated systems may lead to false accusations, damaging reputations unjustly.	52	56	1	3	6	118
4	Setting up sophisticated fraud detection systems requires significant investment in technology and expertise.	54	52	4	3	5	118
5	Monitoring and analyzing data for fraud detection may raise ethical and legal concerns related to data privacy.	53	57	3	1	4	118
6	Effective fraud detection helps my organization comply with legal and regulatory frameworks, avoiding penalties.	51	52	8	2	5	118
7	Fraud detection ensures that contracts are awarded to deserving bidders, promoting healthy competition.	54	56	6	1	1	118

Source: (Field Survey, 2024)

3.1.2 Decision Rule

The null hypothesis is rejected when the p-value is less than 0.05; if not, accept the alternative hypothesis (HA). The table below shows the results of the Pearson correlation method. The null hypothesis states that artificial intelligence does not enhance procurement fraud detection in the deep-water mining Industry in North Central, Nigeria, was rejected when the p-value (000) was less than the critical value (0.05). On the contrary, the alternate hypothesis states that artificial intelligence enhances procurement fraud detection in the deep-water mining industry in North Central, Nigeria. was accepted when the p-value (000) was less than the critical value (0.05). The result confirms a significant positive linear relationship between the independent and dependent variables.

3.1.3 Test of Research Hypothesis

Table 4: Result of Pearson Correlations

H02: Artificial intelligence does not enhance procurement fraud detection in the deep-sea mining industry in North Central, Nig		AI	BR
AI	Pearson Correlation	1	.994**
	Sig. (2-tailed)		.000
	N	118	118
PFD	Pearson Correlation	.994**	1
	Sig. (2-tailed)	.000	
	N	118	118

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Source: (SPSS Version 25)
**. Correlation is significant at the 0.01 level (2-tailed).

AI Represents Artificial Intelligence
PFD represents Procurement Fraud Detection

Table 5: Descriptive Statistics

	Mean	Std. Deviation	N
AI	23.80	24.795	118
BR	23.8000	24.82030	118

Source: (SPSS Version 25)

3.2 Discussion

The general objective of this study focuses on leveraging cutting-edge technology adopt on procurement fraud detection in the deep-water industry in North Central, Nigeria. The findings of the research hypothesis using Pearson's correlation revealed that artificial intelligence positively influences fraud detection in the deep-water mining industry. The findings are in harmony with the literature's previous work of Andrzej (2023) which highlights the importance of integrating advanced analytics into procurement systems to improve procurement practices (fairness and efficiency).

4. Conclusion

4.1 Conclusion

The Pearson correlation result revealed that cutting-edge technology, artificial intelligence positively influences procurement fraud detection in the deep-water mining Industry. This further showed that AI has the potential to significantly contribute to the development of a more open and sustainable industry ecosystem when paired with strict human control and a dedication to moral behavior.

4.2 Recommendations

The study recommends are as follows: a) Managers are advised to deploy digital technologies to monitor and track marine mineral production, supply chain activities, and financial transactions of firms. This will help firms to enhance transparency, trust, decrease human errors, and improve data quality. b) Employee capacity and personal upskilling should be established to equip staff with the necessary technical and regulatory techniques, particularly as technologies evolve. c) Organizations should implement comprehensive, technology-enabled risk management systems that consolidate operational, financial, and compliance risks into a single, manageable structure. d) To address high operational costs, businesses should explore intelligent automation to streamline processes and reduce human error.

4.3 Contribution to Knowledge

This study advances trust-disruptive theory by connecting emerging technology and procurement using deep-seawater or marine mineral sectors. By introducing systems that ensure transparency, data integrity, and accountability, technology plays a central role in preventing fraud and restoring trust among all stakeholders.

The study provides deep-water mining industry and other organizations with new insight on how to proactively assess and manage procurement problems leading to the cost of adopting new technology and staff development, and compliance demands.

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